One in Five Remains

Managing the complex problem of sugar kelp loss in the Skagerrak strait

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The interdisciplinarian will never work alone. It is the constructive opportunity of working within, then creating, liveable futures for the whole of the planet and its human family, and at all scales of attention, that will become the trademark of the forthcoming generation of environmental scientists.

- Timothy O'Riordan (2000)

Mari Svolsbru

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Deciding a topic for a master thesis seems to often lead to a narrow and peculiar theme. Loss of sugar kelp is not a widely known problem and I think I can say for certain that most of the people in my life have heard more about this than they ever would – even if the issue should gain its deserved attention in the media and public. Thank you all for listening to my rants about a brown alga that resemble an overgrown tagliatelle.

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Mari Svolsbru, Oslo 22.05.2013

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1 INTRODUCTION

Since the Rio Convention on Biological Diversity in 1992, the loss of biodiversity has been on the global agenda of urgent issues that need to be addressed (CBD undated1). Anthropogenic influences on the global environments have exploded in pace with population growth, economic expansion and technological advancements (Walker & Salt 2006). Very few, if any, environments on Earth are completely isolated from one another, thus local environmental problems may have causes taking place far away. This thesis is about the extensive loss of a brown alga called sugar kelp (*saccharina latissima*) in the Skagerrak strait. In a little over a decade 80% of this alga has disappeared in this area, meaning that only one in five remains. This is an example of a complex environmental problem with causes that span across local and global scales.

Complexity demands a lot from management, and traditional management approaches are no longer appropriate to face many of today's environmental problems. Previously, management strategies have been limited to addressing individual problems, rather than looking at how issues are interlinked. The present challenge is therefore to explore the possibilities of adapting the management systems in response to complex issues that cross different sectors and levels, and to see how new knowledge can be applied to achieve the best possible results. This is necessary in order to maintain the ecosystem services that human beings rely on.

Building on approaches to address complex environmental problems, the application of new knowledge and the implications for management systems, this thesis explores the case of sugar kelp loss in the Skagerrak strait. The overarching question that I will answer through my analysis is: *What are the challenges to the Norwegian management of the complex environmental problem of sugar kelp decline?* This question is too big to answer in its entirety in a master thesis, and I have therefore chosen to look more closely at the challenges within one sectorial aspect, namely the connection between sugar kelp, water management and agriculture. Agricultural runoff is a source of nutrients that cause eutrophication; i.e. growth of phytoplankton causing darkening of coastal water that is harmful to sugar kelp. I will look at the overarching question by answering two questions: First, *how is the runoff from*

agriculture addressed in the Norwegian implementation of the Water Framework Directive? In answering this question I will discuss knowledge transfer between science and management with a focus on complexity and uncertainty. This leads me to the second question: *How are Norwegian management systems today adapting in order to address complex problems?* This question addresses the way decisions within sectors are applied with sensitivity to external factors. Together these questions form the foundation for the analysis of management of sugar kelp and may provide some insight to the larger issues of managing complex environmental problems.

In the background of this thesis I will describe sugar kelp on the basis of available literature. Further, I will outline the current monitoring programmes and management structures that are relevant for improving the state for sugar kelp. In the theory chapter I have focussed on clarifying central terms and concepts in environmental literature. Furthermore, I discuss new approaches to science and management. In the methods chapter I outline my scientific world-view and describe the process of working on this thesis. I also describe more about the interview process. The analysis is divided into three parts. Firstly, I discuss the reasons for sugar kelp loss and the uncertainty in science. In this part I also outline the scientists' account of management structures. Secondly, I describe the implementation of the WFD in the Glomma river basin district. Here, I bring forth the viewpoints of people who work with water management and agriculture. Finally, I synthesise the contents of the two previous chapters in a discussion on management systems relevant to sugar kelp in Norway.

1.1 Sugar kelp loss in the Skagerrak

Sugar kelp is a brown macro alga that forms large marine forests in protected waters along the coast of the Skagerrak. Its importance in the ecosystem lies in its ability to form a habitat that provides food and shelter for a vast number of other species. In 2002 a sudden drop in the stock was registered, and after the initiation of a monitoring programme the reduction was estimated to be stable at around 80% loss, with some variability from one year to another. This one in five loss may be indicative of causing severe reductions in other species and adversely affecting the functions of marine ecosystems in the Skagerrak. The decline is a threat to biological diversity and the access to ecosystem services for humans, as described below. The reasons for the decline are complex, to some extent uncertain and they span across several sectors

and levels. These traits of the problem demand a lot from the management approach and it is therefore important to explore whether traditional approaches to environmental management are up to the task, or if new approaches can be applied.

The Skagerrak is subject to interlinked environmental problems caused by millions upon millions of small and big actions across the globe: Water mass exchanges with polluted waters from the north-eastern Atlantic Ocean, the Baltic Sea and central European rivers; nutrient runoff from agriculture that cause blooms of algae leading to depletion of aquatic oxygen levels; overfishing; global climate change; urban growth; changed settlement patterns; ocean acidification; invasive species; and sea level rise are all issues that affect the biodiversity and overall state of the Skagerrak strait (e.g. McQuatters-Gollop *et al.* 2009, Moy *et al*. 2009, Intergovernmental Panel on Climate Change 2008, Mee *et al.* 2008, O'Riordan *et al.* 2000, Miljøstatus.no 2012b, Drange *et al.* 2011). These issues are interlinked in causes and outcomes and they all touch upon the issue of sugar kelp loss. The magnitude of the causes, lack of alternative practice options, political and administrative distances domestically or across national borders, and time lags of effects makes the issues difficult to address. In the population, as well as with the decision makers, there is a cognitive distance to take in the severity of problems in marine environments; they are hard to witness or they have seemingly no direct consequence to our daily activities (Mee *et al.* 2008).

There is uncertainty concerning the exact causes for this decline, but the theories revolve around two main processes and one triggering event. The first theory involves the darkening of water, due to algae blooms causing eutrophication and increased levels of other particulate matter obscuring the water column. Without sunlight the sugar kelp is unable to use photosynthesis to produce enough sugar for growth, and for energy to perform respiration. When the water temperature increases in the summertime the plants need more energy to breathe. The high temperatures in combination with high levels of nutrients give sudden growth to quickly responding smaller algae that cut off some of the solar radiation. In effect the plant is unable to breathe and will ultimately choke and die (Bekkby & Eikrem 2012, Moy *et al.* 2009). This cause is the main focus of my thesis, and is the reason for the investigation of measures to reduce agricultural runoff. The second theory involves the food chain and the overfishing of cod. Predatory fish, like cod, would normally eat the smaller fish.

With reduced cod stocks the smaller fish, for example wrasse, grow in numbers. The smaller fish eat snails and crustacean that normally would keep the plants clean of layers of algae, among others filamentous macro algae that bloom under the aforementioned conditions of heat and higher levels of nutrients. Thus, diminishing levels of snails and crustacean compromise the sugar kelp's access to sunlight (Moy *et al.* 2009). The triggering event that may have pushed the ecosystem into a new state, was the exceptionally warm water temperatures in the summer of 1997. In addition, both 2002 and 2006 were registered to be warm to the extent that it would be harmful for sugar kelp (Moy *et al.* 2009). The plausible explanation for the reduction is that with the two other causes already putting pressure on the sugar kelp population, the total exposure was too high and the stock dramatically declined.

Many factors pressuring at the same time is likely to make a reinforced effect. All of the circumstances that are believed to have an effect have some uncertainty connected with them. However, there may be other additional reasons and unknown variables that influence the drastic decline of sugar kelp. The field of ecology is complex and must consider factors that spans across a wide array of categories. Biologists, zoologists, climatologists and geologists who have devoted entire careers to studying their field still make new discoveries. In light of this, the structures that are used to manage complex problems that involve these and many other fields must be flexible enough to incorporate new knowledge. This requires knowledge, not only on nature as a separate entity but also knowledge about how this is interlinked with human settlement, economy, law, and politics. The selection of likely causes to sugar kelp loss above requires action in different sectors and on many levels, which in turn require management systems to look across fields and administrative levels.

As mentioned, four out of five sugar kelp plants in the Skagerrak have disappeared in the past decade. However, monitoring efforts now indicate that the stock has stabilised at this reduced level, and is not considered threatened as a species (Moy *et al.* 2009). Still, the Norwegian Red List for Ecosystems and Habitats define sugar kelp as endangered (EN) in the Skagerrak strait (Norderhaug 2011). However, it is important to note here that the label endangered counts for sugar kelp as a *nature type*, not a *species*, meaning that the plant itself is not facing extinction.

1.2 World-views

Although many of the causes for sugar kelp decline can be categorised and mitigated separately, these issues are connected to one another, sometimes in a way that is not immediately clear. Marine ecosystems function in ways that are only partly understood, and thus unpredictable outcomes are experienced as a result of interactions among known and unknown variables. When mitigation of environmental problems demands great costs in changed practice, and there is uncertainty connected to the causes, why risk costly action that may not work? Worldviews and related discourses become important in answering this question. Drawing on what Dryzek (2013) refers to as a survivalist discourse, the answer to environmental problems would be to promote human security, as humans rely on ecosystem services to survive. Throughout history, humans have innovated in order to protect themselves and to grow, to the point where many no longer recognise their dependence on natural systems. Environmentalism from this point of view is ultimately about promoting long-term human security. Depletion of resources and extinction of ecosystems and species reduce our future ability to innovate and to extract the supplies that are needed to survive. However, another way to look at it is to think of the environment through the perspective of *deep ecology* (Næss & Sessions 1984), where the natural world has an intrinsic value outside of human needs and purposes. The implications of this perspective would include a call for radical change in human practice – in ideology, management, consumption and growth.

Mitigation of environmental problems is often met with questions of costs and benefits. However, this question can be turned the other way around: What is the cost in the long run of *not* acting on a degrading environment? The perspective that is the foundation for this thesis is the planetary boundaries discourse, presented by Rockström *et al.* (2009). They consider the present state of the global environment to be captured by the notion of the *anthropocene era*, where human influence is driving planetary change. By pushing several of the planetary boundaries at the same time, human actions are currently changing ecosystems to the point where great shifts in ecosystem services can be expected. This perspective considers humans part of the environment in a *socio-ecological system*. In order to face the challenges of the future there is a need to promote *resilience*, "the ability of a system to absorb disturbance

and still retain its basic function and structure" (Walker & Salt 2006:1). From this planetary boundaries perspective the question of cost and benefits points to the costs in human lives and livelihoods. From a deep ecology perspective the sense of value is more connected to the values of the sanctity of life – both human and non-human. I will proceed to use the planetary boundary perspective in this thesis, although the idea of an intrinsic value of nature is nevertheless valid. The idea of precaution as a fundamental value in management systems is inherent in these perspectives.

1.3 Ecosystem services and sustainability

The high level of activities on land and at sea in the Skagerrak strait contributes to many of the causes of decline in marine ecosystems. However, there is a need to find ways to take land and coast in use without reducing the quality of the ecosystem. Ecosystem services are the values and services that humans gain from the environment. They are divided into four categories; provisioning, cultural, regulating and supporting ecosystem services (Millennium Ecosystem Assessment 2005). The first one refers to the natural resources that are extracted, like fish and algae for human consumption, and the second to the recreational and traditional values of nature. Regulating ecosystem services are the ecosystems ability to resist and repair damage for example the ability to absorb excessive CO_2 levels or other pollutants. Finally, the supporting ecosystem services make up the foundations for all the other ecosystem services: It is the ability of the ecosystem to reproduce itself and maintain its own functions. It is the primary production of biological material and the complex function of the ecosystem as a whole that builds the foundation of all the other species involved.

In the planetary boundary perspective mentioned above, the fourth type of ecosystem services – the supporting ecosystem services – provides the justification for a precautionary use of natural resources. The term sustainable development was coined by the Brundtland Commission as: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development 1987:43). This term coincides with securing the fourth type of ecosystem services, *the supporting services*, i.e., the ecosystem's ability to reproduce itself. Any resource extraction that compromises the possibility of future generation's use will be inconsistent with sustainable

development. This is ultimately about underpinning resilience in the ecosystems. In this thesis I treat the human use of resources as a given. Nevertheless, the manner of the use, the management of human practices and the effects of human presence in nature, should not go unquestioned. The application of the terms sustainable development and ecosystem services can aid the balancing act of permitting the use of natural resources. Deciding the boundaries of how to extract resources involves the challenge of weighing interests when there are conflicting goals. For example, there is an expressed goal to keep the opportunities for recreational activities along the coast as well as maintaining agricultural practice in adjacent land areas and permitting fishing for the relatively few fishing boats that are left in the region (The Ministry of the Environment 2009b). And all these activities must be conducted without harming the ecosystems ability to reproduce itself.

1.4 Choice of scale and perspective

An important line of thinking in protection of marine environments is that the planning process ought to consider the activities on land and in the sea together. This suggests that the municipality level is suitable for regulation of coastal areas as these already are responsible for the regulation on land. However, there are land-bound activities far away from the coast that have consequences for the marine environment, calling for a regional view. In addition, the complexity requires a critical look at sectors that perform very different tasks. How can it be ensured that environmental problems are seen in a broader context? This wider perspective needs to be applied on multiple scales and across a wide array of sectors. Therefore it is also necessary to apply a trans-scale and trans-disciplinary framework. For this I have chosen to look at adaptive co-management and its coastal equivalent, integrated coastal zone management. For a scientific perspective on the connection between knowledge and management, I use post-normal science and co-production of knowledge.

The literature on sugar kelp loss is limited to public documents and studies from the natural sciences. I found this issue to be interesting to consider from a social scientific point of view. Due to the contested science behind it I have chosen to use a lot of space in the thesis to describe the algae and the factors that contribute to its decline. The analysis is largely a product of the social sciences and written from a post-modern constructivist perspective in an inductive and explorative style. The lack of

social scientific viewpoints on the topic have made the analysis challenging. However, the issue might enlighten other aspects of complex systems analyses than those found in more common research topics, like climate change and adaption.

2 THE AREA AND THE MARINE NATURE TYPES

2.1 The Skagerrak strait and the Oslo fjord

Map 1: Map of the Skagerrak: Retrieved from Wikimedia Commons under the terms of the GNU Free Documentation Licence (version 1.2).

The Skagerrak strait runs between the Jutland peninsula of Denmark and the stretch of coast spanning from the southeast coast of Norway to the southwest coast of Sweden. The strait has a saline deep-water inflow from the North Sea (Store Norske Leksikon undated1), and water exchange with the Baltic through Kattegat, where the brackish

water runs as a current at the surface (Store Norske Leksikon undated2). The part of the Skagerrak that is referred to in this thesis is within the coastal areas of Norway.

The Oslo fjord is located on the south-eastern coast of Norway, and is commonly divided into the inner and outer part, the first being a relatively shallow fjord stretching like an arm into the country, the latter forming the wider opening of the fjord and is also a part of the Skagerrak strait. The Oslo fjord is not important for fisheries on a national scale. However, there are some local fishermen depending on local fish resources, as well as people fishing for sport and their own consumption.

The whole stretch of coast in the east of Norway is under severe building pressure. This area of the country is the most densely populated and most of the medium and smaller sized towns in the region are growing in population. Along with expanding urban and suburban areas of the coast, the sparsely populated areas are desirable as space for second homes for recreational activities, weekend visits, and summer breaks.

There are reports of sugar kelp loss and other changes in the ecosystems along the Skagerrak strait, both in Norwegian waters and internationally (e.g. Moy *et al* 2009). The research on sugar kelp loss used in this thesis is from the Norwegian part of the strait. The coastal area selected for a review of water management in this thesis is in the eastern part of the Skagerrak, in the Oslo Fjord. For this analysis the southern parts of the watershed is considered, which includes lowlands with forests and agricultural activity, mainly cereal production. Considering the wider region is important for water management as all streams and rivers in the watershed end up in the ocean. The state of the freshwater resources is connected to the state of ecosystems along the coast.

2.2 Sugar Kelp Forests

Sugar kelp (*Saccarina latissima*) is a marine brown algae species that is found in relatively protected waters along the Norwegian coast (The Directorate for Nature Management 2007). Sugar kelp attaches to hard surfaces like rocks, smaller stones, or seashells with a root-like holdfast between 1 and 30 meters below sea level. It forms a long flat leaf-like structure, called a blade. The blade is normally between one and three meters long. The plant is perennial, meaning that it lives for more that two years,

normally between three and five. It grows in relatively protected areas with low levels of wave exposure. On the west coast, where the regular kelp[1] is dominant, sugar kelp is also found in less wave-exposed areas and in between the regular kelp plants at depths where the latter grows sparsely. In favourable areas sugar kelp is capable of supporting ecosystems of great biological diversity and in massive volumes. In fact when the algae form forests; three-dimensional landscapes on the seafloor, it is one of the most productive marine nature types in the world, both in terms of primary production of biological material and in sustaining an impressive number of other plant and animal species. The marine forest provides small fish with food and hideouts (Bekkby & Eikrem 2012, Moy *et al*. 2009).

Image 1: Sugar kelp in 1992, replaced by filamentous macro algae by 2002. Adapted from Moy *et al.* (2009:19) with permission.

Since the sugar kelp forests holds a remarkable number of species, many of them identical to the ones found right on the shoreline, it can function as a species and gene bank. When other nearby ecosystems experience stress, for example in the event of an oil spill, a depopulated shoreline can experience repopulation from a healthy sugar kelp ecosystem at slightly deeper waters (Bekkby & Eikrem 2012).

The total biomass and extent of sugar kelp are uncertain. However, The Norwegian Institute for Water Research (NIVA) estimates that the Norwegian coast holds somewhere between 5 and 25% for the world's total stock of sugar kelp (Bekkby & Eikrem 2012). As the weight of a dead blade from a sugar kelp plant is greater than

[1] Kelp (*Laminaria hyperborea*) is the term for this alga, but I will refer to it as *regular kelp* to avoid confusion with sugar kelp.

the water that surrounds it, dead plants will sink and be carried out to oceanic depths. The biomass is then assumed to be sedimented, thereby sequestering carbon out of the carbon cycle. Sugar kelp is substantially smaller in volume than the regular kelp forest and does not contribute as much to the carbon sink function as the latter. Nevertheless, the current reduction in biomass from sugar kelp is estimated to be 100 million NOK[2] worth of non-sequestered carbon, on the basis of the 2008 price of CO_2 emissions (Moy *et al*. 2009).

In 1997 scientists began to suspect that there was a sudden decline of sugar kelp. More research results pointed in this direction in 2002 and a monitoring programme vas initiated in 2005 to document the extent of the phenomenon. A loss of approximately 80% was found (Moy *et al.* 2009). The estimations of presence and loss are assumed to change from one year to another as well as seasonally, for example due to temperature flux. The plant re-establishes well in areas that are not covered by filamentous macro algae. It is also important to note that the sugar kelp does not continue to decline. Since the monitoring started in 2005 the stock has increased and decreased from one year to another but not declined further to face extinction (Moy *et al.* 2008).

2.3 Replacing communities

The species that replace sugar kelp consist of many, and are labelled filamentous macro algae or silty turf algae communities. Thorough descriptions can be found elsewhere, for example in NIVA (2007), Moy *et al*. (2009) and Moy & Christie (2012). Here I will only describe the central traits with these species that makes it hard for the sugar kelp to re-establish, and the reasons for their occurrence.

The filamentous algae largely consist of thin threads that resemble long, loose wool fibres. They respond quickly to high temperatures and increased levels of nutrients in the water and will therefore in certain periods outgrow other surrounding plants. They lie on top of the existing vegetation and receive the sunlight before it can reach the plants below. Water flux tears the thread forming algae apart, and this is one of the

[2] Approximately 12 million EUR, calculated on the basis of the average currency over the year of 2008. Average calculated from monthly data from Norges bank.

reasons that the sugar kelp is under more pressure from silty turf algae than regular kelp: As mentioned, the sugar kelp prefers less wave exposed areas. The Filamentous algae communities consist of several species, some of them toxic (NIVA 2007), and some invasive or introduced (Moy & Christie 2012).

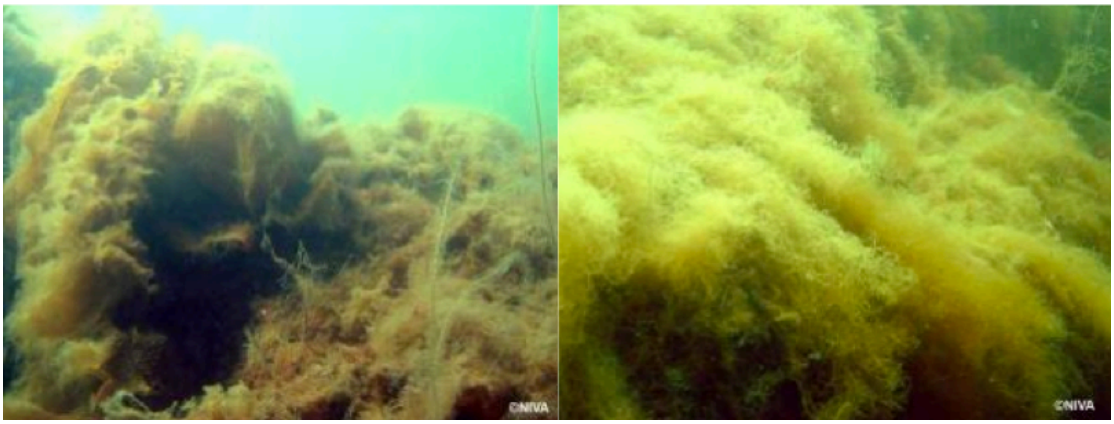


Image 2: Left: Sugar kelp overgrown with filamentous macro algae. Right: Filamentous macro algae without the presence of sugar kelp. Adapted from Moy *et al.* (2009:20) with permission.

Image 3: Left: Sugar kelp overgrown with epiphytic algae. Right: Healthy sugar kelp blades. Adapted from Moy *et al.* (2009:20,iv) with permission.

When the sugar kelp is overgrown with loose algae and epiphytes,[3] as shown in the image below, it cannot perform photosynthesis. The prevent the sunlight from getting to the sugar kelp and it dies. The currents carry the sugar kelp away, and the filamentous algae remains and constitute its replacement. The biomass in these communities is far lower and this new ecosystem cannot support anywhere near as many individuals as sugar kelp forests. The reduction in presence of animal species is

[3] Epiphytes are attached algae growing directly on the blades of sugar kelp.

found to be 33%, whereas the numbers of individuals are reduced by approximately 75% (Bekkby & Eikrem 2012).

Drawing on the descriptions above it is clear that the traits of sugar kelp and filamentous algae are an unfortunate combination. In the context of increased nutrient runoff coupled with increase of average sea temperatures in the summer, the changes seen in the marine ecosystem in the Skagerrak can be expected to prevail. Therefore addressing agriculture as a source for nutrition is crucial for sugar kelp. I will address agriculture in the second chapter of the analysis.

3 DEVELOPMENTS IN MANAGEMENT AND SCIENCE

A range of new developments is happening within nature management at this time, both in scientific contributions to the field, and in the government's management of coasts and water resources, and biodiversity in general. Here I will first outline the foundation of these developments in the Convention on Biological Diversity, second the main activities within the scientific community, third the developments in relevant environmental management practice, and lastly look to international efforts that Norway takes part in and benefits from.

3.1 The Convention on Biological Diversity

The Earth Summit, arranged by the United Nations in 1992 in Rio de Janeiro, Brazil, resulted in three declarations on climate change, desertification and biological diversity. These three declarations are considered intrinsically linked and need to be seen in relation to one another (CBD undated1), nevertheless only the latter will be central in this thesis. The Convention on Biological Diversity states three goals; firstly, the conservation of biological diversity; secondly, sustainable use of its components; and lastly, equitable sharing of gains from genetic resources (CBD undated2). In 1993 Norway ratified the Convention on Biological Diversity. One promise made through the ratification was to map the biodiversity in Norwegian territory. Mapping is the basic premise as a means to monitor the loss of biological diversity, find tools to halt and eventually reverse it (The Directorate for Nature Management 2007).

	Achieving the Aichi Targets by 2020
A	Address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society
B	Reduce the direct pressures on biodiversity and promote sustainable use
C	Improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity
D	Enhance the benefits to all from biodiversity and ecosystem services
E	Enhance implementation through participatory planning, knowledge management and capacity building

The Aichi targets, adapted from the United Nations Decade on Biodiversity (undated).

The Rio Convention commits the countries to continued participation, and the recent focus is on the Aichi targets for the United Nations Decade on Biodiversity. We are now well into this decade, where the goal is to implement the Strategic Plan for Biodiversity for the period 2011-2020 in order to halt and reverse loss of biodiversity (United Nations Decade on Biodiversity, undated). The table above shows the Aichi targets that Norway as one of the governments that have signed the Convention on Biological Diversity have agreed to.

The work on how to incorporate the Convention on Biological Diversity led the Ministry of the Environment to publish a handbook in 1999 describing different nature types in Norway (NIVA 2011). The first handbook on the marine environment was released two years later. Both handbooks were updated in 2007, and their purpose is to provide the necessary description of those nature types that is to be mapped among the existing natural resources. This was the beginning of the national Programme for Mapping Marine Biodiversity that is described in more detail below.

3.2 The scientific activities on marine biological diversity

This section describes the publicly funded scientific efforts made in research, mapping, and monitoring of both sugar kelp and biodiversity in general.

3.2.1 The National Programme for Mapping Marine Biodiversity

The National Programme for Mapping and Monitoring of Marine Biodiversity in Norway[4] has since 2007 provided detailed data on the presence of selected nature types along the Norwegian coast. The scientific work has been conducted by NIVA, The Institute of Marine Research (IMR), and the Geological Survey of Norway (NGU).

The mapping of the marine nature types in Norway mainly covers the marine areas out to the baseline (NIVA 2011). The Norwegian coast is to a large extent fragmented with fjords and islands, and the baseline follows straight lines drawn from the outer tips of the headlands as well as the outer islands. This means that there are vast coastal areas within the baseline. Formally the programme corresponds to the

[4] The programme has later changed its name to The National Programme for Mapping Marine Biodiversity, as the role of monitoring is moved to the Coastal Monitoring Programme.

Planning and Building Act, as well as the Water Framework Directive, in its goal to map the nature types up to one nautical mile outside the baseline. However, the mapping is prioritized in the areas that are close to the coast and the areas with shallow waters, both for the sake of feasibility and because these areas are the most vulnerable to human activity, which makes detailed mapping there a more pressing issue (The Directorate for Nature Management 2007).

The programme maps a range of nature types, among them sugar kelp. The data that is obtained through the programme will aid the municipalities in producing area plans that are both precise and predictable in terms of reducing conflicts around the balancing act of using and protecting natural resources (The Directorate for Nature Management 2007). This mapping will gradually provide each municipality with detailed information on the nature types they administer under the surface of the ocean. Over time this will require adjustments in the local policy on marine management. This is a slow process where the municipalities one by one receive complete or partial geographical detailed data sets. The mapping is not yet complete and the progress for the upcoming years depends on continued financial support.

Detailed mapping of the coast is time-consuming and costly due to the inaccessibility, and examining every square meter of the seabed is not feasible. To deal with this researchers have developed models in Geographical Information Systems (GIS) to make predictions of expected locations for nature types. The GIS modelling uses parameters like slope, wave exposure and depth to make maps of likely sites for various selected nature types. The modelling is followed by field examinations like diving, filming or using water binoculars that provides point data. The findings on site are used to verify the accuracy and to adjust the use of the parameters in the model. The result is map data with overviews of nature types with probability levels of occurrence of the nature types (Soldal *et al*. 2009).

3.2.2 The research on sugar kelp

After the indication of great loss of sugar kelp in 2002 the phenomenon was confirmed through a pilot programme in 2004 in cooperation between the University of Oslo and NIVA. Here an absence of sugar kelp was registered in 90% of the stations measured between Lindesnes and the Swedish border, in total 108 locations

along the Norwegian part of the Skagerrak (Fredriksen *et al.* 2011). In the time between 2005 and 2008 further investigations were done in The Sugar Kelp Project to identify the extent of the problem and possible causes. The final report from this project, written by Moy *et al.* (2009) describes an approximate loss of 80%, and discusses the various causes.

3.2.3 The monitoring programmes

In the aftermath of the above mentioned research a monitoring programme for sugar kelp was established in 2009 (NIVA 2012a & 2012b). This programme is now being discontinued along with the Coastal Monitoring Programme. They will be replaced by a new programme called ØKOKYST (Doffin 2012).

3.2.4 The Norwegian Nature Index

The Directorate for Nature Management published the first edition of the Nature Index in 2010. The index is meant to make an overview of the state of the natural environment and collect information in one place. The index includes the major ecosystems; forest, mires and wetlands, open lowland, fresh water, coastal waters, and the open sea. Each of these has selected species within the main species groups that function as indicators. They all receive a number between 0 and 1 to indicate the state of the species, and are averaged to indicate the state of the ecosystem it belongs to. The reference state is given the value 1, and is the estimate of a population that is sustainable. Lower numbers indicate deviation from the reference state, and suggest that improvements can be made. Averaging these numbers quantifies the overall state of biodiversity in Norway, while the specific numbers are available for each species and ecosystem along with scientific assessments of which actions are necessary and urgent in order to protect them. The goal of the Norwegian Nature Index (NNI) is to organise the available data into a more comprehensive form that makes prioritisation easier for decision makers. This is intended to make the management tasks related to halting the loss of biodiversity more efficient (The Directorate for Nature Management 2013).

3.2.5 The Norwegian Red Lists

The Norwegian Biodiversity Information Centre has since 2005 worked to provide information on biodiversity in Norway. They have a focus on threatened species, ecosystems and habitats as well as an overview on invasive species. The Red Lists are

assessments of a species risk for extinction and consist of one document on threatened species and one on ecosystems and habitats. The methods used to assess species and ecosystems are developed by the International Union for Conservation of Nature (IUCN), and the Norwegian data is shared internationally through the Global Biodiversity Information Facility (The Norwegian Biodiversity Information Centre 2011, 2012a, 2012b).

Sugar kelp was a part of the Norwegian Red List for Species in 2006, but was removed from that list in 2010 as the remaining stock proved to be stable, thus not at risk for extinction as a species. Instead sugar kelp was added to the Red List for Ecosystems and Habitats that was first published in 2011. There they consider sugar kelp as a *nature type* endangered (EN) in the Skagerrak strait on the basis of the 80% loss registered in this area. In the North Sea the status is vulnerable (VU) (Norderhaug 2011).

3.3 Public management and relevant legislation

Following the ratification of the Convention on Biological Diversity, Norwegian legislation has been adapted and specified to include the commitments. Here is a brief overview of the legislation aiding planning and management.

3.3.1 Legislation and whitepapers for municipal planning

The Norwegian planning system has a strong decentralized tradition, where the built environment is regulated in the Municipal Area Plan. This plan must be in accordance with the regulations in the Planning and Building Act as well as other sectorial legislation with specific guidelines for a wide array of sectors. Examples of such laws are the Water Regulation[5] and the Nature Diversity Act, both described further below. These laws are passed on a national level in the Parliament and they provide the municipalities with planning tools that both restrict and open up opportunities for the more specific plans that are voted over on a local level. A recent and relevant change is the Planning and Building Act of 2008 [implemented in 2009] that has committed the local municipalities to work closer with marine environments. Since 1989 the coastal municipalities has had the right to plan for the sea areas, but the revised Planning and Building Act gave a responsibility to the local municipalities to include

[5] The Water Regulation is the EU water framework directive integrated into Norwegian legislation.

marine areas in their planning. The coastal areas within the jurisdiction of the municipalities coincide with that of the Water Framework Directive: one nautical mile from the baseline. For municipalities with many islands that means a greater responsibility for large sea areas.

When the Norwegian government on a state level decided to sign and ratify international agreements like the Convention on Biological Diversity their next task was to pass laws that transferred the responsibility to the local level so that the new political goals could be incorporated into the municipal master and area plans. In the aftermath of the Rio Summit the work has been slow but steady. Passing laws and developing national strategies takes time. Through the white papers "Stortingsmelding 58 (1996-1997)" and "Stortingsmelding 42 (2000-2001)" the Norwegian Parliament expressed the particular responsibilities the municipalities have in protecting biodiversity (The Directorate for Nature Management 2007). The aforementioned work on mapping the nature types provides the overview of the local fauna and flora that is crucial for the municipalities to be able to manage biodiversity in a sustainable manner.

3.3.2 The Constitution of Norway

In the summer of 1992 the Parliament added the precautionary principle and the concept of sustainable development to the Constitution of Norway.

> Every person has a right to an environment that is conducive to health and to a natural environment whose productivity and diversity are maintained. Natural resources should be managed on the basis of comprehensive long-term considerations whereby this right will be safeguarded for future generations as well.
>
> In order to safeguard their right in accordance with the foregoing paragraph, citizens are entitled to information on the state of the natural environment and on the effects of any encroachment on nature that is planned or carried out.
>
> The authorities of the State shall issue specific provisions for the implementation of these principles. (Constitution of Norway undated, Article 110 b)

3.3.3 The Nature Diversity Act

Further effort was put into the new Nature Diversity Act, which entered into force in 2009, and replaced earlier less specified legislation. This act made the precautionary principle part of Norwegian law. Another important trait in this legislation is the use of specific nature types that is to be protected outside of natural reserves. This allows

the state to prioritise key nature types that are crucial in order to protect certain species or to ensure biodiversity and further force the municipalities to use this information in their planning (The Ministry of the Environment 2009c.).

3.3.4 The Water Framework Directive

In the mid-nineties, the European Commission found that the legislation on water quality was fragmented across Europe. In order to coordinate efforts and establish a more coherent framework for coping with water issues the European Union Water Framework Directive (WFD) was established in 2000. It has since been subject to some minor adjustments.

The result of the commissions work was a directive that sought to streamline water policy with a focus on both surface and ground water. River basins have a central focus in the WFD because these make the natural boundaries that distinguish one water system from another. This means that the whole watershed; the rivers, streams and groundwater that end up in the same location on the coast, is defined into one river basin district where the water quality is managed jointly. A central aim is to aid the management of these water systems across administrative and political boundaries, and sometimes even national borders. The ultimate goal of the WFD is to achieve good ecological and chemical status for all waters by a set deadline. There is a special focus on valuable habitats, drinking water and bathing waters. These three foci are aimed at specific areas within a river basin, whereas the goal for good water quality is overarching (European Commission 2012).

The directive's jurisdiction is all bodies of water up to one or three nautical miles off the coast, depending on the country (Mee *et al.* 2008). For most countries within the EU this means a main focus on fresh water resources. However, since Norway has a vast coastline and very fragmented landscapes with many islands, even with the boundary set to the lower limit (one nautical mile from the baseline), this leaves a tremendous area of the sea within the jurisdiction of the WFD.

In Norway the WFD was in place in 2009, but the integration of the framework was in place through the Norwegian Regulation on a Framework for Water Management[6] already in 2007 (Vannportalen.no undated1). The WFD is largely managed on the county level. The County Governors within the different watersheds cooperate to form plans for water management.

One of the foci for the County Governor is working closely with frameworks for agriculture. Agriculture in Norway is exempt from the pollution legislation, meaning that the common pollution from agriculture is not illegal. The farmers are still committed to avoid excessive pollution and there are specific rules for example for treatment of manure (Regelhjelp.no undated). Due to the exemption from the pollution legislation the work with reducing runoff from agriculture is based on volunteer participation, mainly through the regional environment programmes (RMPs), further described in chapter seven.

3.4 International efforts relevant to Skagerrak

Due to water exchange with the Baltic Sea, the Kattegat Sea and the North Atlantic, international frameworks are relevant for the water quality in the Skagerrak. Here I will outline some of the international efforts that are important for water quality, and thereby fro sugar kelp.

3.4.1 The BERAS Implementation

Due to its narrow connection to the Atlantic through the Kattegat sea and the Skagerrak strait the Baltic has a low level of shift in water masses. Therefore it is vulnerable to accumulation of nutrients and eutrophication, both in the coast and in open water (McQuatters-Gollop *et al.* 2009). About 50 per cent of the sea floor in the Baltic sea is considered dead, and agriculture is one of the main sources for this. The Baltic Ecological Recycling Agriculture and Society (BERAS) is a transnational project for countries surrounding the Baltic Sea. The BERAS implementation is partly financed by The European Union and Norway, and the goal is to develop alternative agricultural practices that reduce runoff. In Europe 80 per cent of the crops are used as animal fodder, and by replacing cereals for fodder with grazing fields of clover and other nitrogen fixating plants can bind the soil in between crop rotations. This

[6] Commonly referred to as The Water Regulation (*Vannforskriften*).

requires agriculture that is based on a combination of grazing livestock and cereal production. The research done on this shows great results (BERAS undated2), but the implementation of it is challenging, as will be further outlined in chapter seven.

3.4.2 The OSPAR Convention

The OSPAR Convention for the Protection of Marine Environments in the North-East Atlantic is an extended and updated convention based on the 1972 Oslo Convention to prevent dumping and the 1974 Paris Convention to prevent dumping from offshore industry and land-based sources. The agreement between 15 countries with watersheds ending up in the North-East Atlantic was signed in 1992. The OSPAR Convention works with five central strategies on biodiversity and ecosystems; eutrophication, hazardous substances, offshore industry and radioactive substances. All five strategies are coordinated in the Joint Assessment and Monitoring Programme (OSPAR Commission 2013).

3.4.3 The Marine Strategy Framework Directive

As a part of a more coherent water resource and environment strategy the European commission developed the Marine Strategy Framework Directive (MSFD). This directive holds similar goals for the marine areas as the Water Framework Directive does for freshwater resources. A central goal is to achieve 'good environmental status' within agreed time frames, where the definition includes diversity and sustainable development (Mee *et al.* 2008).

It is decided that the MSFD is not to be integrated with the European Economic Area (EEA). Norway is not a full member of the EU, only of the EEA and therefore the MSFD is not yet integrated into Norwegian policy. However, improved marine management in neighbouring countries can be expected to benefit Norway (Europaportalen 2011, Miljøstatus.no 2012a).

4 CONCEPTS AND THEORY

Loss of sugar kelp is an example of an environmental problem with many layers of complicating factors. In order to make sense of the management approach to such a problem there is a need for a sound theoretical framework that can be translated into effective policy and action.

In this chapter I will discuss the central terms used in environmental theory and clarify the way I use them here. The concepts important to sugar kelp to are sustainable development, nature, socio-ecological systems, and ecosystem services. Further, I will consider perspectives from holistic management, post-normal science, co-production of knowledge, adaptive co-management, and finally see how these fit into integrated coastal zone management.

4.1 Definitions of key concepts

Many concepts regarding nature are disputed, and our understanding of nature in turn determines how we understand concepts like sustainability and the place of humans on this planet. Thus our understanding of the relationship between humans and nature influence policy. Castree (2001) argues that the exploration of the tension between nature and humanity is, and should be, central within the discipline of geography. At present, there are fewer environments untouched by humans than ever before. Issues regarding the environment are complex, spans across all levels, and their long-term outcome will be determined by human actions in the near future (Rockström *et al.* 2009). In order to avoid confusion I use some space to briefly illuminate disputed concepts that are central to this thesis. This will clarify the way the definitions are used in this paper. In the other chapters there will be short definitions of less disputed terms, summarised in the appendix along with a short definition of the terms treated here.

4.1.1 Sustainable development

The term sustainable development has been highly disputed ever since it was defined by the World Commission of Environment and Development (1987:43), commonly referred to as the Brundtland Commission. The commission coined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". The dispute

revolves around the tension between the words 'development' and 'sustainable': While the concept of *growth* is intrinsic to development, sustainability requires of humans that we limit our activities within the *constraints* of the environment (Robinson 2004). Thus the idea of everlasting growth is contested due to the finite availability of resources on the planet. Robinson (2004) points out that peoples understanding of the concept sustainable development is dependent on ones position in the spectrum of discourses on nature-human relationships. This leads to fundamentally different interpretations of the same term, which can lead to a false sense of agreement in policy and practice. Governments and companies have been the most eager to implement the concept of sustainable development in policy and practice, whereas in academia and in the environmental movement the term is more disputed. The idea of finite resources in nature suggests that aiming for growth will make it impossible to allow future generations the same access to ecosystem services as the present generation. Ecosystem services will be discussed further below.

4.1.2 Nature

In our daily speech we use the term 'nature' as if it were self-explanatory. Although most people do not spend a lot of time considering where they draw the line between nature and non-nature, one rarely doubts the definition that one bears in mind. So, what is nature? This is not a simple question to answer. The question is of great importance because the notion we have about nature to a large degree determines our approach to environmental issues (Demeritt 2001). To dig a little deeper into the first question; is there a distinction between humans and nature? Between society and nature? Between the built environment and nature?

The answer to the question 'What counts as nature?' is not unproblematic (see Box 1). The understanding determines the legitimacy of environmental policy (Castree & Braun 2001). If one limits the definition to the pristine and untouched, the policy implication might lead to the choice of only preserving the nature that is, or seems to be, untouched by humans. This perspective is concerned with viewing nature as external to society (Castree 2001). Historically, this perspective has led to the preservation of nature in reserves without human presence, sometimes even with evictions of indigenous peoples (e.g. Brockington 2005). Castree (2001:3-4) points out that the separate view of 'people and environment' is criticized for being

inadequate in the task of interpreting the dynamic attributes of the relationship

With extracts of 100% natural origin (Palmolive hand soap 2013).
Take a moment to interpret the message on the soap container. Here, the blurry outline of the concept nature is expressed through the word 'origin'. Is not every single thing in this world of natural origin? A simple example might be the plastic container the soap is in; the plastic is made of crude oil, which originates from biological material that has been covered in sediments and exposed to high temperatures and pressure for millions of years. Thus, the origin is from nature, although the production of plastic is made possible through human technology. Plastic containers do not belong with the flora and fauna in ecosystems and can cause quite a lot of damage when disposed of in nature, therefore it is a common understanding that plastic is not natural. It is likely that the intention of the message is to express that the fragrance oils in the soap are made from natural ingredients. Regardless, the quote itself can be interpreted as a common expression of nature being on the outside of culture, a distinguished 'other'. As Watts (2005:143) puts it "nature might be culture's other but there is much traffic, a veritable information highway, between them".

Box 1 An everyday example of an unclear distinction between human culture and nature.

between society and nature. There are of course many perspectives on where to draw the line between society and nature. Here I will contrast the dualistic interpretation of the human-nature relationship with the integrated view of socio-ecological systems.

In Castree & Braun's (2001) perspective a critical approach to break up the dichotomy involves 'de-naturalizing' nature. Castree (2001) explains that the view of nature is socially constructed, and that an alternative is to explore the fusion of society and nature. In the post-structural view language is recognised as the mediating factor that makes the foundation of knowledge, and language is not neutral. Thus 'de-naturalizing' is the process where the definitions are revealed as social products and considered critically.

Yet the idea of nature as a social construction is criticised for ignoring the reality and autonomy of nature outside of human influence (Castree 2001). As well the notion can be interpreted as a reductionist notion that 'nature is *nothing more* than a social construction' (*ibid*:16). Castree (2001) point out that these critics may be exaggerating the constructivist view: The critiques are only valid if they target hyper-constructivist views. Demeritt (2001) argues that the constructivist view criticise the notion of an objective knowledge of nature. Human observations are biased by socially constructed cognition. The framing of these claims comes from examples through history where science have been proved wrong in conceptions of nature, for example through the infamous misconceptions of the causes of desertification (e.g. Brockington 2005, Savory 1991.) A constructivist approach is useful for critically viewing nature-human relationships as interlinked, allowing alertness to issues that may otherwise be ignored. Arguably, the criticism of it does not hit the mark, as the constructivist view does not necessarily deny the existence of nature itself, but rather describe the limitation in the human conception of it.

4.1.3 Socio-ecological systems

What Watts (2005) describes as an 'information highway' between nature and culture clearly expresses that these are not spheres isolated from one another. Redman *et al.* (2004) argue that the traditional approach of studying the fields of ecology and social science separately is out of date. Further the authors criticise the traditional ecosystem studies framework for including human influences as static elements. They call for an interdisciplinary approach and efforts to create frameworks to address interlinked social and ecological systems. The term socio-ecological systems (SES) capture the notion that there is feedback in both directions in this relationship: ecological systems limit and enable social systems and *vice versa*. Both human and natural systems change, adapt and continue to influence one another in a dynamic interconnection.

Holling (2001) frames this system using the concept of a *panarchy*: Ecosystems and socio-ecological systems consist of hierarchies and adaptive cycles. He describes adaptive cycles of resource exploitation, conservation, release of the resource and reorganisation of the practice of exploitation. This process is eternal, and happens on all scales in a hierarchy. He holds that this framing allows for a better approach to complexity. Instead of being overwhelmed by a large number of interacting factors he

proposes an understanding of complexity that focus on a smaller number of controlling processes. The small-scale fast processes of innovation and exploitation experiments with the systems capacity. From above the large-scale slow systems respond and allows for regulation of practice.

The aim of ecologists to study the long-term dynamics of ecological systems cannot be met without viewing the dynamic influence of humans (Redman *et al.* 2004). After all, Redman *et al.* (2004:161) says, "almost all human activity has potential relevance to global environments". Thus, static or non-inclusion of social systems in ecology would leave a vacuum in research, possibly biasing outcomes. Similarly, social systems depend on ecosystem services, as further investigated below, and the long-term conditions for human development will not be comprehensible without an understanding of environmental change. It is also important to note that there is no linear relationship between humans and the environment: what will be considered as resources and constraints depends on the political context and the technological manner of resource extraction (Castree 2001). The relationship will vary in time and space in pace with ecological and societal dynamics.

4.1.4 Ecosystem services

The growing awareness of the effect of human activities on natural systems have led to alternative ways of framing the relationship between humans and the environment. The concept of ecosystem services widens the view of what attributes in nature that provide human livelihoods. The concept can be divided into four categories: provisioning; cultural; regulating; and supporting ecosystem services (Millennium Ecosystem Assessment 2005).

Firstly, the provisioning ecosystem services are the resources humans extract directly, like foods and materials for clothing and tools. This service is perhaps the first that comes to mind for most people when thinking about what humans gain from the environment. Yet, this service alone represents a limited understanding of ecosystem services. Considering the other three categories in addition to this opens up for a broader view of the human-nature relationship.

Secondly, the cultural ecosystem services encompass the traditional and recreational values humans find in nature. In a Norwegian context, it is the experiences available to all for recreation; a walk in the forest, a bonfire on the beach on Midsummer Eve, or fly-fishing in a river. Fishing is arguably the extraction of a resource; a use of the aforementioned provisioning ecosystem service, but the experience in itself is traditional and recreational. Cultural services are also the resource sold through tourism, for instance as whale-safaris or mountaineering on the western and northern coast.

Thirdly, regulating ecosystem services are the traits of the ecosystem that resist and repair damage. It is the biogeochemical process when plants and animals absorb carbon, nitrates and phosphorous released into the environment, or the binding of pollution and chemical compounds that can be harmful. In the ocean the binding of carbon in plant material contributes to stabilise the pH levels, countering ocean acidification, as well as being a carbon sink, slowing down global climate change (Bekkby & Eikrem 2012).

Lastly, the supporting ecosystem services are the functions in the ecosystem that makes it reproduce itself and maintain all the other ecosystem services (Millennium Ecosystem Assessment 2005). This is not a resource used directly by humans, but it is fundamental for providing the other services. Another distinguishing factor is that the supporting services form over longer time scales. It is the total of the bound compounds in biomass, the nutrient cycles, and the water cycle. It also includes the plant's and algae's production of oxygen through photosynthesis.

The term ecosystem services express the array of functions in nature on which humans rely, and with this in mind it is easier to notice what is at stake if the boundaries of these services are pushed too far. The future is likely to hold some drastic changes in these functions. Tuvendal & Elmquist (2011) point out the importance of recognizing that the direct benefits to humans from ecosystems often spring out from ecosystem services that are distant in time and space. For example, the ecological functions required to provide the sea with fish take place on a wider scale than the location of the fisheries. This creates a challenge in management where

the locations of the beneficiaries are distant in time or space from the ecosystem that must be managed sustainably.

In this thesis, the understanding of nature is integrated with human culture. In the time of the *anthropocene* the global influence of human activities have made us part of all ecosystems (Steffen *et al.* 2007). Humans have the ability to critically evaluate their effect on natural systems, and ought to control their actions in order to avoid degradation that will undermine the very natural systems that they depend on. The view of nature as a social construct is linked with the postmodern constructivist perspective of this thesis.

With these definitions in mind I proceed to outline the theoretical framework for this master thesis, which focuses on new approaches to environmental management linked to new approaches to science. The science and management paradigms I wish to focus on are partly overlapping: Holistic management, co-production of knowledge, adaptive co-management, and integrated coastal zone management.

4.2 Holistic Management

Savory & Butterfield (1999) promotes holistic thinking in management. Their basic assumption is that previous unsustainable management approaches have a common denominator: The lack of considering goals up against consequences in other sectors at present or in the future. This perspective is one of width and longitude. Central to holistic management is to plan for a wider spectrum of effects across sectors, thus enabling revelation of what would otherwise be unforeseen side effects. The outcome of plans formed after this principle is thus more likely to be similar to its intentions. Reality is the whole, and dividing management into parts can blur the prospect of outcomes. The authors claim that this way of thinking improved management outcomes regardless of what you manage for.

However, their main focus is sustainable land use management informed by many years of experience with scientific failure, i.e. the failed attempt of preventing desertification in Africa through reducing the numbers of grazers (Savory & Butterfield 1999). In the aftermath of this Savory put a lot of thought into the reasons

behind the failed land management he had partaken in. The result was the framework of holistic management.

Savory & Butterfield (1999) emphasise that identifying conflicting goals are key to forming better management. The inclusion of economic, social and environmental needs and realities at the same time are crucial for designing sustainable plans. Putting these elements into a holistic goal involves a clear vision of the type of future development that is desirable. Furthermore, this goal must be put in the context of all available resources, and the resources that will be required in the future. Together this forms a picture of long-sighted holistic thinking.

4.3 Post-Normal Science

Post-Normal Science (PNS) is a scientific concept that attempts to break with the mainstream understanding of science in academic circles and beyond.
Ravetz (2004) paints a grim picture of the contemporary role of science in society. He argues that commercial interests have taken over as a driving force for determining what to study. This type of mainstream science, he claims, falls within a reductionist tradition that fails to take many perspectives into consideration. Problems are reduced to single components and reassembled to supposed knowledge of the whole. This approach will ignore complex aspects of a problem that are only visible if seen in its totality. The mainstream science does in this sense not promote safe knowledge. In issues of high stakes and systems uncertainties appropriate methodological tools are not applied by mainstream science. As an alternative Funcowitz & Ravetz (2003) propose the post-normal science of precaution.

A central issue to Ravetz (2004) is that the science of today has gone far in the principle of assuming that applying an innovation is "safe until proven dangerous" (Ravetz 2004:348). This must be turned upside down: A new discovery should be proven to be not harmful before it is applied.

> *We can no longer separate 'nature', 'science' and 'society'; the combination of lifestyles and markets drives innovation in the science-based industries, and their cumulative effect is to further disrupt the complex natural systems on whose stability we all depend. But the environmental effects are downstream, and so are often delayed and diffuse* (Ravetz 2004:348).

This quote expresses a deep concern for the human practice of today. In the context of environmental degradation it also connects this to a serious concern; that we do not connect our actions directly to the outcome in nature due to delay as well as consequences that are difficult to link directly to a specific cause.

An important criticism of the mainstream science is the fact that we now are facing issues where the old methods no longer will suffice: The traditional method of dividing a system into individual, isolated pieces, understanding those, and reassembling these components into a whole misses some of the complex traits of that system (Ravetz 2004). Thus, the method may lead scientists to miss knowledge about possible problems. An alternative method is needed, where we look at systems as integrated, crossing fields of understanding various aspects of the issue and consider several world-views in approaching the problem. Ravetz (2004) propose these traits in combination with a strong focus on precaution. The precautionary approach is "concerned with reacting to the unintended harmful effects of progress" (*ibid*:349), where progress is a concept integrated in the aforementioned market driven approach to innovations and discoveries.

Precaution is vital to coping with the unknown. Funcowitz & Ravetz (2003) further argue that the complex issues science is facing today involve a higher level of uncertainty, coupled with higher risk. In issues where the stakes are low and the system certainty is high, the traditional framework works well. However, in issues with both high stakes and a high degree of system uncertainty, precaution is the only safe approach. Environmental challenges are increasingly found in this position of uncertainty and risk, therefore this framework is appropriate for environmental science and ecology.

4.4 Co-production of knowledge

Sheila Jasanoff (2004) pick up some of the same concerns as Ravetz, in the notion that the connection between knowledge, society and markets are increasingly messy, and accounted for in deterministic ways. Her central argument is that knowledge is inseparable from social practices, thus it is always value laden. The concept of co-production seeks to bridge the gap between knowledge of nature and knowledge of society while simultaneously criticising both realist and purely value-laden notions of

reality. Co-production sees the spheres of nature and society in co-evolution and is thus coherent with the aforementioned idea of socio-ecological systems.

In opposition to the value-laden view promoted by Jasanoff, authors like Bramwell (1989 in Asdal 2003) seek to liberate natural science from political ideology. Her starting point for this notion is her view of the environmental movement from the 70's, where she paints a picture of a movement seeking to integrate radical leftist green values with science and society. Her criticism lies in her opposition to the anti-progressive, and the voices that promote un-developing and going back to nature. Mainly this is an objection to the more radical branches of green romanticism within the environmental movement (e.g. Dryzek 2013). In the defence of integrating political values with natural science there is the above-mentioned idea that values are never truly disconnected. There is more to the advocacy of integrating values with conceptions of nature than promoting un-development. Bruno Latour, for example, bring forth ideas that resonate with the PNS-framework of precaution:

> To force us to move slowly we must discuss nature, politics and science at the same time (Bruno Latour 1999, in Asdal 2003:66-67).

While Bramwell and Latour share the view of nature as a social construct (Asdal 2003, Demeritt 2001) Latour criticise the view she represents for being "obsessed with liberty" (Asdal 2003:66). Her stand on this is coloured by her focus on racial and gender bias in nature discourse, a strand of criticism that will not be discussed further here. For more on this see Anderson (2001) and Moeckli & Braun (2001).

Latour is known for using the actor-network framework to describe the coexistence between humans and nature (Asdal 2003). He gives nature agency along with humans and thus "the human subject is no longer in the center with its power to create worlds. The non-humans are also drawn in as co-producers" (*ibid*:72).

Co-production as a framework for enhanced understanding of knowledge can be used as a tool for social scientists to prepare for interdisciplinary work. Considering the magnitude of global problems and the failure of producing solutions on a single discipline's terms there seems to be an increased need for frameworks that function across disciplines. When facing issues in the coastal zone there is a call for a

theoretical framework that understands threatened ecosystems in the ocean in terms of coupled socio-ecological systems. The ideas mentioned centre around locally anchored governance, stakeholder participation, trust, flexible knowledge systems and precautionary strategies when met with uncertainty. The concept of integrated coastal zone management has the potential to embrace all these traits.

4.5 Adaptive Co-management

Redman *et al.* (2004) claims that the notion of socio-ecological systems requires further development of comprehensive frameworks to tackle ecological issues. Adaptive co-management is one such framework that takes ecology and social structures into account in environmental management.

Adaptive co-management embraces stakeholder participation. It is defined by Folke and others as "a process by which institutional arrangements and ecological knowledge are tested and revised in a dynamic, on-going, self-organized process of learning-by-doing" (Folke *et al.* 2002 in Schultz *et al.* 2010:662). The participation can either cut across levels of decision-making or different types of ecological knowledge. This description shows traits that by necessity give great variation in how projects are organised. Thus, the comparison of projects is challenging and has led to much dispute of the approach's efficiency.

Currently, the trend in management of ecosystems is the involvement of a wider range of stakeholders (e.g. O'Riordan 2000). Over the past decades the participation-paradigm has been gaining ground in research, policy and practice. Yet an example of this shift is the integration of the concept of participatory planning in the Aichi Targets for the United Nations Decade on Biodiversity (undated), outlined in chapter three.

The advantages to involving a diversity of actors are many. Schultz *et al.* (2010) point out that efficiency, accuracy and legitimacy are improved factors in projects and processes with stakeholder participation. They argue that being an active part of forming the decisions and plans motivates the actors to follow up their commitments and thus improves the efficiency of the project. As well, the accuracy of the plan is improved when a wider range of knowledge is the foundation of the management

scheme. Lastly, the legitimacy is greater when the people who are touched by the project are encouraged to participate.

Schultz *et al.* (2010) point to qualitative studies that both criticize and celebrate adaptive co-management. The projects that seem to have worked well report that cooperation enhanced innovative approaches, and that the actors found win-win solutions increasing ecosystem services. The sceptical voices showed to examples of participants stalling action in projects, and worried that participation may slow down projects. Schultz *et al.* (2010) use this debate as the backdrop on their quantitative study on UNESCO Biosphere Reserves, where the criteria for the projects correspond to traits of adaptive co-management. By asking managers in these reserves to report their experiences, they found that participation showed no negative effects, except a slight decrease in results when involving NGOs in implementation. They found that the adaptive management projects did not enhance the quality of biodiversity conservation, but they did improve social and economic development in the process. They underline that the development results they found were not at the expense of conservation goals for biodiversity.

Adaptive co-management approaches environmental protection with consideration for existing and potential future human activity and seeks to balance these interests (Olsson *et al.* 2004). Solutions aim at creating a minimal impact for social and economic systems as well as for the ecosystem that human activity depends on. The strategy gives room for specifying and adapting the approaches to both human and environmental needs.

Brugere (2006) stresses that homogeneity in participants, along with agreed upon purposes for the project is a precondition for successful collaboration. One can raise the question though; how adaptive is homogeneity in participants? This view is arguably not very ambitious, and is underpinned by the assumption that collaboration is likely to fail if the involved stakeholders have conflicting interests. In the coastal zone the likelihood of such opposing interests is very high. Thus it becomes important not to declare failure when met with stakeholders with diverging values and motivations.

Olsson *et al.* (2004) suggest that a precondition for adaptive co-management to work is to avoid a top-down approach. The self-organising model is superior in meeting challenges with local sensitivity. Conflicts can be addressed and resolved within the group through a management process when there are high levels of trust. With an overview of the available local resources and options new solutions can be found that minimise the stakeholders losses where they have to give up some of their interests. A key factor is good leadership to enhance the self-organisation process and address conflict. Stokke (2004) also found this as an important factor in a study of the network for management of the Vansjø-Hobøl river basin in Norway. His interviewees reported that the leader was trusted in conflict resolution because she was an outsider that was considered to be neutral in the conflict and attentive to the stakeholders needs.

Both Stokke (2004) and Olsson *et al.* (2004) emphasise that building trust is crucial for local collaboration. Arguably, this can mitigate the supposition of Brugere that heterogeneity is undesirable. In order to overcome the challenge of conflicting interests the actors must feel that they are included, heard and that they do not lose disproportionately to the other stakeholders. Brugere (2006) also points out that the group size must not be too big.

4.6 Integrated Coastal Zone Management

As one of many specifications of the need to protect biodiversity the UNCED Rio Conference in 1992 recognised the value of considering questions of land use and coastal use in context of one another (Brugere 2006). It was recognised that the land-water interface consists of particularly vulnerable ecosystems that require a precautionary approach in planning and management. After these needs were clearly stated a response from international agencies were to implement integrated coastal management

A challenge to managing coastal zones, O'Riordan *et al.* (2000) says, is the failure to recognise how physical and ecological systems are interconnected. The coastal zone includes spaces of varying characteristics and needs, and thus the different management bodies connected to them are often separate. The task of looking at these spheres together can be quite challenging: In order to manage beaches and headlands,

the open sea and the adjacent land areas together there is a call for an integrated perspective.

Central to the concept of integrated coastal zone management is the combination of adaptive management and a view for the integration of social and biogeochemical processes (O'Riordan *et al.* 2000). The latter is linked to looking at coastal environments as socio-ecological systems. Due to the adaptive approach making a rigid framework for how this should be conducted is not desirable. However, some key elements of integrated coastal zone management can be summarised:

Firstly, sensitivity to ecological and geophysical processes is crucial. In the coastal zone there are resources that humans extract, and the processes that maintain these (O'Riordan *et al.* 2000). As discussed above, the concept of ecosystem services (Millennium Ecosystem Assessment 2005) capture and refine this sensitivity, by distinguishing between the provisioning, cultural, regulating and supporting ecosystems services. O'Riordan *et al.* (2000) emphasise that in cost-benefit analyses all these traits needs to be addressed and calculated in. The flattening of what is valuable may lure us into overexploitation and cause surprising responses in natural systems. By viewing the coastal zone as a life-support system long term interests are addressed.

Secondly, there is a limited knowledge of the socio-ecological system. Planning and management must work within the realm of the existing knowledge yet take uncertainty into account. Marine systems are incredibly difficult to study and monitor due to inaccessibility, and the systems at hand are very complex. Therefore it is necessary to leave "room for ignorance" (O'Riordan *et al.* 2000). Jentoft (2009) points out that with factors like climate change and sea level rise we must also face the unknowable. Not all things are possible to predict, and thus management must leave some leverage to face unforeseen events.

Thirdly, there is the challenge of promoting agreement in projects with multiple objectives. There are many stakeholders with conflicting interests in coastal issues, and some of these must accept losses. Promoting common goals and involving the stakeholders that must make sacrifices is important for achievability.

Lastly, the management scheme must be responsive. In the process of managing socio-ecological systems one must balance contradicting objectives and manage conflict. This process requires trust and communication. For the process to be locally grounded information and scientific basis must be available to all, and the stakeholders must be included to advocate their own needs.

All of these objectives will take a different form depending on the local context and the existing social and political frameworks, along with the variation of ecological needs.

Brugere (2006) argue that building local capacity is crucial to integrated coastal management. The idea of relocating the responsibility to local governments is embedded in the idea that these are flexible and more capable of defining the local context and the local needs. Such capacity building is time consuming and unlikely to be implemented if the transaction costs is higher than anticipated.

Brugere (2006) relies on new institutional economics to inform her analysis of the potential of integrated coastal management. This perspective disputes certain basic principles of neo-classical economics, such as the assumption of fully informed decisions and rational choices. She argues that in coastal management new institutional economics is better suited as a framework due to the many uncertainties: There is neither sufficient information about ecosystems nor a complete overview of stakeholders in the market, civil society and elsewhere. Brugere (2006) further argues that information is often limited and unbalanced between actors, and the management institutions might enhance integration of as many actors as possible if this limitation is recognised.

4.7 Summary

The theory basis for this thesis is grounded in the notion of coastal environments as part of socio-ecological systems. The relationship between human beings and the environment must be explored and managed with sensitivity to needs in both systems. Availability of the full range of ecosystem services will in a long-term perspective require adaptive capacity and precautionary approaches. Particularly where there are

high stakes and low levels of certainty precaution becomes crucial. These insights have implications for management systems: Where there are complex challenges in socio-ecological systems management must find ways to integrate efforts within many fields.

The involvement of stakeholders is significant in order to create locally anchored management schemes that take human and ecological concerns into account. Furthermore, adaptive management and integrated coastal zone management as a basis for management approaches can enhance the total effect and work towards consensus for sustainable futures. In the case of sugar kelp, this approach has the potential not only to solve this one problem, but to address wider spectres of issues at the same time.

5 METHOD

This study is a qualitative case study based on interviews, public documents and scientific works. In this chapter I will elaborate on the methodological choices I have made in the process of working with this master thesis. This includes a clarification of my scientific point of view, a justification of the choice of method, an overview of my working process for this thesis and some reflections about the interviews.

5.1 Scientific world view

This thesis is written from a systems perspective, where the idea is to look at complex environmental problems. The basic premise for this is the acknowledgement of humans as a part of nature, and therefore I have grounded this work in the socio-ecological systems perspective. Human presence and actions have been part in moulding the natural systems, and has historically marked the surface of the earth. At this time in history there are traces of human practice in the ocean, in the atmosphere and on larger areas of the land than ever before. This work is founded in the idea that the current geological epoch have moved from the *holocene* to the *anthropocene*, where human influence have interfered with the cycles of carbon, phosphorous and nitrogen, thus changing the premises of natural systems (Steffen *et al.* 2007, Rockström *et al.* 2009).

Nature have at all times been limiting and enabling the human course of action. Now, that population numbers have exploded and technology allows extraction resources at a higher rate than ever, humans are faced with a choice for the future and need to reconsider the level of acceptable change in the environment. To further explore these serious issues I use a post-constructivist perspective: In the debate over positivism, the social sciences and humanities claimed humans as a fundamentally different object of study than nature and material objects. Humans have language and are subjective beings with agency, and can thus not be treated as an objective given. Applying this line of thinking also to the natural world opens up for ideas that humans through subjective language construct nature through frameworks of understanding and the language applied to describe it (Asdal 2003). Constructions of the understanding of nature correlate with the creation social systems. Understandings of

nature further decide how it is treated, and the perceived importance of revising the human place and practice on this planet. With this as my viewpoint I do not deny the existence of nature outside the human mind. If no one is present to witness a tree falling in the forest, it still makes a sound.

It is also central to my thesis that I believe that human values cannot be disentangled from our language completely, and that the logical conclusion therefore is to question the notion of objective knowledge (e.g. Jasanoff 2004). A wider account for this view if found in the theory chapter.

5.2 Qualitative method

In applying qualitative methods to social research one is able to embrace subjectivity and different perspectives. Inherent to this method is the requirement that I, as the researcher am alert to my own views, to help identify the implications of subjectivity (Hay 2010). Inherent in qualitative method is the notion that both the researcher and the informant influence the research. In accordance with the post-modern world-view knowledge collected in the interviews are here seen as inter-subjective: in the context of the meeting between the researcher and the interviewee the knowledge is produced (Thagaard 2009).

The post-modern constructivist perspective breaks with the traditional positivist notion of objective knowledge. The views of the researcher and requirements set for research, also in the natural sciences, are considered value laden. Context is therefore crucial in the process of analysis (Thagaard 2009). The way I see it, my ability to see my own perspective clearly and distance myself from it in approaching other world-views is fundamental, especially in treating approaches to issues that I don't agree with. In a systems perspective approach the inclusion of various perspectives is bound to touch upon dissonance, therefore I set as a goal to myself here to treat the various ideas and perspectives with respect, but still allowing my own views to be the filter of interpretation. When looking at the management system as a social construct the understanding of various views are crucial in order to make sense of it.

Exploring the field of water management and sugar kelp loss the theme balances between focus on the structure and the individual. The structures that are created limit

and permit actions form the individuals within it. It also gives a possibility for the individual to break with the structure. Individual accounts tell us about lived experience, but at the same time they reveal information about the structure (Hay 2010). With a post-constructivist viewpoint the structure is interesting for the understanding of management, and my access to knowledge of the structure is partly through interviews of people within the system. Therefore the tools for interpretation require a view for both the individual and the structure. As well, the criticism and the disagreements over the structure become visible in the meeting with individuals with different experiences.

Marshall & Rossman (2011:2) say, "…qualitative research is pragmatic, interpretive, and grounded in the lived experiences of people". In the case of sugar kelp loss, and the various actors involved in approaching it, the lived experience spans from the researchers that have on-site experience of the magnitude and meaning of the issue, to the bureaucrats working with implementing the European Union Water Framework Directive and their understanding of the issue. In between these actors there are layers of interpretation, how the texts on the topic are written, how the issues are expressed in regard to urgency and the tension between knowledge and uncertainty. So many actors have their own lived experience in widely different settings, and their lived experience is on a scale between direct and abstract observation. Therefore I have seen the necessity to know as much as possible from a selection of these stages of filtered knowledge: one actor sees the loss of sugar kelp; another the decline in fish in the sea, another is responsible to reduce nutrient runoff in rivers and streams. These lived experiences are connected, but not necessarily in direct contact with one another. This is where my interpretation and understanding of the different views becomes important.

Marshall & Rossman (2011) claim that qualitative studies takes place in a naturalistic setting: The people that are involved are seen in the environment they act within, not abstracted from their understanding in a limited lab-setting. I have taken this into consideration by interviewing my informants in their place of work. I see this as seeking out people in their natural surroundings: It involves entering their context and their interpretations, and understanding their perspective within the framework of their roles as professionals.

5.3 Case studies

The case study is a research approach that seeks to understand one or a few cases in great detail in order to understand wider phenomena than that of the case studied (Thagaard 2009). In this research project this is linked to the aim of understanding management of complex environmental problems through the case of a sugar kelp loss. Gerring (2007) holds that case study research often have problems with representativeness and thus external validity. Arguably, this depends on what the case is. In the context of environmental problems, where the specifics vary a lot – the systemic traits[7] can be comparable. Thus this case study can inform understandings of complex systems and management approaches.

Picking the case of sugar kelp loss has not been unproblematic: The process of selecting which factors to emphasise has been extremely challenging, due to the complexity of the case. However, the case, which is complex enough in itself, is meant here to illustrate a variety within other complex environmental problems. Both the environment and human institutions are complex, and there is a need to identify a mind-set and a set of tools to approach these issues as they are. However, picking such a wide topic forced me to treat certain aspects rather crudely, arguably – so would any case study of a complex system. The idea is to explore an intricate web of issues that are interlinked; yet coped with in isolated or partly connected solutions. I do this in the hope of presenting it in a somewhat coherent manner, providing the reader with an understanding of the problematic aspects of the management systems today. Gerring (2007) recommends looking at a few cases in depth and at the same time many cases superficially. This approach to case study research suits the complex systems theory well and coincides with my choice of outlining abroad picture while specifically addressing one of the complex traits, namely agricultural runoff.

This study is mainly inductive, and the theory is selected to fit the case, in contrast to the deductive approach of selecting a case in order to prove or disprove a theory. However, throughout the research process the theories that I knew of in advance called to be used when I found that they fit. Therefore the research process can be said

[7] For example systemic traits as described through Holling (2001) in the theory chapter.

to swing between deductive and inductive states, and thus can be seen as abductive (Thagaard 2009).

5.4 The path to a research question

This project began with an idea that was nothing at all like the project turned out to be. Having grown up by the sea, I have a general interest in the political and social development in Norwegian coastal issues. My initial idea was to pick up the debate over privatised space along the coastline in a political geographical perspective. I started out exploring themes of property rights, illegal building and free access for the public in the 100-meter belt along the coast. After some digging in the field and a talk with my subsidiary supervisor I found out that the most recent developments in coastal management in Norway lay in the mapping of marine biodiversity, along with some interesting developments in water management. Reading about the mapping process made me aware of the dramatic decline in two marine nature types: eelgrass fields and sugar kelp forests, and I decided to look at how these were managed by the municipalities.

With a foundation in this material I intended to write about the plans in one specific municipality in the Oslo fjord. I started reading studies on marine biology regarding the Norwegian coast as well as the municipal area plan of a specific municipality in detail. My idea was to do a document analysis of the municipal area plan, but as I read the documents I kept making notes with questions that could only be explained to me if I conducted interviews. It seemed to me that analysing pieces of the text in a context of theory I had picked out seemed fair neither to the intention of the plan nor to the people who had written it. Realising that a discourse analysis of way the municipal area plan was phrased would possibly be of limited interest, I sough to conduct interviews with several planners in different municipalities. This could potentially shed light on new developments in municipal Norway.

After this realisation I found myself in a new methodological position; I would need to conduct interviews. Most of the issues I wanted to discuss would regard information that is public. Even so, I was in no position to foresee what kind of issues would be raised or how willing my interviewees would be to express frustration, insecurity, lack of knowledge, or reveal practice that could be criticised. My intention

was not to catch the municipalities in malpractice, but rather to assess the management approach in respect to complexity. Regardless, my access to information could increase with ensuring anonymity, and this could be of high value to my analysis. Anonymity would be easier if I talked to planners in several municipalities.

Up until the above-mentioned turning point of realising that I needed interviews, anonymity and a wider selection of municipalities, the process of preparing myself for the writing was quite messy. As much as I appreciated the liberty of being able to pick a topic freely, it was also utterly paralyzing to have a jungle of issues and approaches to choose from. I spent a lot of time reading about a wide array of coastal issues; the planning documents in the municipality that I initially wanted to study; different research projects; national policy documents; different coastal management theories; and other wide theoretical frameworks. I took in all sorts of information without a clear idea on how to organise it, and I did that for a longer time than I care to admit. Luckily, it was not all in vain: That part of the process allowed me to see some of the complexity in coastal management, although overwhelming, it was also very inspiring. I was critical to what I read and in so doing I was entirely subjective, but at the same time I got to know the field and established some idea of competing discourses and interests in coastal issues.

Once I conducted the first interview I quickly discovered that there was a good level of awareness in managing eelgrass fields and protecting these in the municipal planning process. The planner I spoke to, however, did not know about the issues related to sugar kelp. I discovered that this was a far more compelling theme to me.

In a group supervising with my subsidiary supervisor I was met with a choice I needed to take: The issues of sugar kelp is largely a question of eutrophication and agricultural runoff and cannot be met by planning in coastal municipalities alone. The issue of sugar kelp loss would therefore need a regional approach. The management of sugar kelp and eelgrass are addressed on separate scales, and I could stick with eelgrass and stay on the municipal level or move on to the regional level. With the feeling that the eelgrass issue was well handled in municipal planning practice I decided to go with the underdog: *How could such an enormous decline in a nature type go largely unnoticed in our society?*

With the new focus on sugar kelp I was heading into a field of seemingly higher complexity in the range of approaches that could help the state of that particular nature type. Management of eelgrass is mainly takes form through mapping of its sprawl providing municipal planning planners with an overview. Developments that conflict with presence of eelgrass are usually stopped due to accessible policy tools for managers on this issue. However, there is less attention on sugar kelp in municipal planning, often because it grows in areas further away from land that are generally less prone to be a site for developments. Thus the issue seems to be abstract from the purpose of local planning. The threats to sugar kelp are complex and encompass issues on all possible scales. For example, working with eutrophication is done on a regional level, and available measures spans across many institutional sectors. For this reason complex systems theories led me to look across several institutions and scales for my analysis.

The choice to work with sugar kelp led me closer to something I was truly dedicated to working with. Again, I began collecting all the threads of the background information and theories I had worked with, and I was left with the question of whom to interview. This turn slowed me down as the new framing required other knowledge. Also I had to change my project description and apply for approval from the Norwegian Social Science Data Services (NSD). This slowed me down further, as I could not contact any of the informants I wished to speak to prior to the approval of my new research project.

5.5 Interviews

When I had changed my research question the hunt for informants started over. I had already interviewed a municipal planner anonymously and although my research question had changed radically I found that this interview informed my framing. Much of the insight from previously collected information could still be used.

In conducting qualitative research Flowerdew & Martin (1997) stress the need to pick informants on the basis of being illustrative but rather than being representative. To me, the importance of remembering this was to avoid falling into the trap of thinking that all voices have the same weight. The boundaries of this project made it

impossible for me to speak to and present all relevant actors, and represent them equally. I only had room for some perspectives, but I kept my eyes open to the fact that a multitude of perspectives exist outside of the ones I chose to examine. Representative data in this sense is not, and should not be of my concern.

I began my new search for informants with approaching researchers that have expertise on marine biology and sugar kelp. These interviews were very useful in terms of double-checking my understanding of the literature, but particularly in getting a better understanding of the uncertainties involved in the field, which is hard to get a grasp on from papers, reports and documents. Although the scientific papers I have read are written with the appropriate disclaimers, I had not realised just how many insecurities there were. As well these researchers provided me with their understandings and concerns of current management systems.

To get a clearer understanding the work to implement the Water Framework Directive I started recruiting informants in the County Governor in Oslo and Akershus. First I turned to the Agriculture and Food department, as they were the ones working up against farmers. Farming practice is an issue that is really important in implementing the WFD, as a ploughing leaves the soil exposed for erosion and leaks nutrients into rivers and streams. This is also where the Norwegian work up against BERAS is found. BERAS is the cooperation between the countries surrounding the Baltic where amongst others causes erosion from agriculture has made a serious ecological hazard.

Mainly I contacted the informants I wished to speak with by e-mail followed by a phone call some days after, to give the informant time to consider whether to participate in the study. My interviews were quite late in the research process, and when one of my interviewees started suggesting people I could talk to I decided to use the snowballing technique, where one informant lead you to the next (Hay 2010, Marshall & Rossman 2011). Early in the process, when I was trying to recruit municipal planners to participate in this study, I struggled a lot with the first recruiting technique. I wanted to avoid calling the municipalities to ask for whom I should speak to in order to avoid problems with anonymity. In the second round of interviews I did initially not intend for my informants to be anonymous. When anonymity no longer was of my concern I still struggled to get answers from some of the people I tried to

contact. With snowballing I found it easier to get people to take the time to see me. Someone they knew and trusted had already spoken to me and recommended me to speak with them, and this was possibly seen as an endorsement for my project.

In total I have interviewed eight people, seven in person and one by telephone. My interviewees are; one municipal planner; two marine biologists; three people in the County Governors office in Oslo And Akershus; one water manager in a sub-district; and one person in an NGO promoting organic farming. Seven of the informants were male and one was female. Where I quote the interviewees I refer to them as 'him' regardless of actual gender. Additionally, I have used information from e-mail correspondence with water researchers.

In the interview situation Flowerdew and Martin (1997) emphasise the need to consider the resulting data in the light of positionality and reflexivity. Are there any power relations involved? Are there any class or gender issues that might influence you as an interviewer or the interviewee? In my case, I am young and female, with limited work experience. I consider it more likely that my position could lead to my interviewees to see me as ignorant, inexperienced, or too young to understand. Overall I feel that the interviews went well and that the people I interviewed took an interest in my work. In most cases I presented the project and showed the level of understanding that I had gained in preparing for the interview. For some of the informants this seemed to place me as an insider, meaning that they recognised that I had insight in the case. However, there were interviews where the informant assumed that my level of knowledge was limited, and where the tone of conversation would make it awkward for me to try and prove myself as insightful. Here, I was probably understood as an outsider and I felt I had to accept descriptions and accounts of things I already knew. The outsider/insider issue, for example described in Hay (2010), was something that I felt was difficult to control. I don't believe that there are only two categories, but rather a continuum between the two. This way I may have gotten access to more information on the themes where I was considered an insider and less on the themes I was unfamiliar with.

Throughout the process of interviewing I tried to avoid allowing the expectation of the implications of positionality take up too much space in my mind. I believe it could

paradoxically have become a part of my own truth about the power-relations, without real concern for the interviewee's perspective, which, regardless would be out of my control. After all, I have a no opportunity to modify the fact that I am young, female and with limited working experience. I believe that not putting too much thought into that particular issue during the interviews might have helped preventing awkward situations that might even have restricted my access it information further. Another way to think of it is to consider my lack of experience as an advantage, as I could ask more basic questions about the way they conduct their work, and how the system works without coming off as dumb.

Another possible challenge is that the interviewees were sometimes interviewed about their performances at work, which means that they may have personal interests in the way the final product is presented. A situation of this kind can bias, or colour the way the informant present their reality, or cause them to gloss over some issues or avoid topics that they are not proud to present (Flowerdew and Martin 1997). Again, it would be very difficult for me to influence this. They held knowledge that I needed, and could not be expected to adopt my perspective on what should be revealed for the purpose of the research.

Flowerdew and Martin (1997) debate the different ways of conducting the interview in terms of keeping a close or distant relation to the interviewee. I could not decide on a specific form in advance of each interview, but rather felt my way as I went along. People are different, and my aim was to allow the interviewee to set the tone for the interview in order to keep them comfortable with the situation. In contrast to other studies where the topic is more sensitive and personal this was not a choice that bore much ethical weight. However, there was one interview where I didn't feel that the interviewee was at ease in spite of this strategy, and perhaps it had been easier for him if I had taken a clearer role. In that situation I felt that the informant did not see the point of the interview, and thus was uncomfortable about purpose of it. In the aftermath of that interview I chose to be very careful of how I used the information I had attained. A discussion of anonymity and quotes from the interviews is found below under *ethics*.

The interviews were conducted in a semi-structured way. Before every interview I adapted a set of questions and themes for possible topics of conversation depending on the background and likely knowledge of whom I was talking to. The semi-structured way of talking allowed the conversations to flow more naturally, so that if the topic jumped into a place I had imagined to come up later I just let the conversation move in its natural direction. If there were any pauses during the interview I would scan the list for topics that had not yet come up. This worked really well. Before I left I agreed with the interviewees that I could ask any further questions by e-mail, and they all agreed to this. I asked each informant if they would agree to record the interview. All informants agreed to this, and it helped me focus on the informants a lot more than I would have been able to if I were to take notes throughout the interviews.

Listening to the recordings of my interviews I realised that in some of them I was very open about my own interpretations of the issues we were discussing. This gave me a foundation that could be a double-edged sword: On the one hand, it helped me test my own opinions, and allowed the informant to correct me if I had misunderstood something. On the other hand, it limited what part of the material I felt I could use. The use of the informants' own opinions turned into an exercise of interpretation where I have been careful not to use quotes from the interviews that I might have "planted" there through triggering a response with critical comments. An unexpected benefit I found was that the opinions I expressed during the interview helped me structure my own thoughts for the analysis. I have a large material of perspectives, ideas, critical comments and interpretations locked in my own head, and I have struggled to define my own view. I found that in a focussed conversation I would express my understanding more clearly. That way I have used the interview material just as much to quote myself as I have the informant.

Due to restricted time I have only partially transcribed the interviews. I found that my time was better spent listening to the interviews several times, make notes and transcribe the parts that were more essential to the analysis. I found this technique to be sufficient because my analysis is less focussed on language than for example a discourse analysis would be. The direct quotes are transcribed and edited to avoid the tone of oral language, which might have been perceived by the reader as statements

with less weight. This is done with sensitivity to the meaning of the quote in the context of the interview.

5.6 Validity

At this time, there are many changes and developments within the field of management of biodiversity and water resource management. Rather big changes in legislation and practice may imply that the findings in this thesis can be out of date quickly. Regardless, I would argue, the work done on this topic is not in vain. It is in the very beginning of a big change that the great things happen. Perhaps I come across some challenges that have this far passed unaddressed? If such challenges are changed over time it is in all likelihood a change for the better.

The state of the coastal environment is determined by a large array of variables, and in this thesis I will not be able to go though them all. There is not enough room for a full description and research of the public apparatus together with an analysis of those management structures. In addition to the limitations in describing the administrative approaches it is also beyond my capacity to understand the full complexity of ecology and the marine biology linked to sugar kelp. Many of the variables are unknown to the biologists and zoologists who have devoted entire careers to study this field. My aim has been to collect accessible information on the subject and present the complexity in as simple terms as possible. Thus, the text will almost certainly be too limited to use as a reliable source to understand the complexity of marine biology and the complete function of sugar kelp as well as the reasons for the loss of it. However, I will attempt to present it in words that make it possible for decision makers and bureaucrats to understand better how we can cope with complex environments that we are bound to somehow survey, plan for, and manage.

5.7 Presenting complex systems

The topics covered in this thesis are parts of complex systems. Presenting complexity in a coherent and structured manner is a great challenge. Since the main aim of this thesis is to address management of complex of socio-ecological systems, I have prioritised information that illuminates a wider understanding. Some places that choice comes at the expense of thorough descriptions of entire management structures. For example, when addressing conflict in water management over

agricultural measures, I have chosen not to describe neither the entirety of agricultural nor water management, only the parts necessary for providing a basic understanding. As well I have focussed on the bits that are related to sugar kelp, and the structures where my informants describe disagreement. One informant says:

> "The implementation of the water framework directive is bureaucratised to such an extent that it is next to impossible for outsiders to understand the organisation of it."

I have obtained a wide understanding of this implementation, but chosen to present only parts of it. For the reader it is important to note that there are many more elements to this than what is described here.

Another challenge for me in collecting material on sugar kelp specifically has been that the sources for information have been spread between various sources. The available documents are characterized by research being performed in bulks. As well, the sources are divided between many institutions, thus connecting the dots have been time consuming. As this issue is addressed over time, and if time series are acquired for longer periods, it might become easier to obtain information collected in one place, but for now this is a challenge with the knowledge base. However, this year the monitoring of sugar kelp is once again reorganised, and the continuous reorganisation makes information accessibility challenging for those who are interested.

5.8 Ethics

All the informants that I have spoken to in this research project got the offer of anonymity, fully or partly. None of the interviewees chose to be anonymous, and were clear about their opinions and where they stood. I made explicit agreements with each one about how they wish to be quoted. This was done differently in each case: In one of the interviews I wrote down notes and wrote it into a text, e-mailed it to my informant and he adjusted the facts and statements into a note that he agreed to be quoted from. Another time I got instructions on which category of quotes I was free to use with the confidence from the informant that I would be able to distinguish between agreeable and disagreeable quotes. However, most of my informants permitted me to quote them freely.

The informant that asked me to not quote certain parts of the interview, made me think that the same might apply to some of the other informants. With a growing discomfort over finding many critical views in the interview material I chose to make all the quotes in the analysis anonymous. This is a choice I have made in order to avoid the possibility of disputes with employers or other institutions. I always refer to the informant as *he* regardless of actual gender. Due to the relatively low number of informants it would have been impossible to hide the informants within the category of their employers. Thus the result is a compromise: I have presented them here as anonymous, but many will be indirectly identifiable. Since all of the informants did agree to being quoted in full name this is not against the ethical design of the study.

I was uncomfortable quoting the informants in full name, particularly those with very critical comments. There is a chance that the mood of the conversation left the interviewee non-alert to their own wording of an expressed opinion. Being in this type of conversation is beneficial for me as the researcher, but using the attained material uncritically can harm the informant. It is not within my capacity to predict which types of quotes that can harm an informant's reputation or their relationship with an employer or institution. Thagaard (2009) focuses on how one can avoid that the informant recognises himself or herself. I don't see this as a central aim in this study as I am not commenting or judging the informants, only presenting their views.

6 SCIENTIFIC KNOWLEDGE AND MANAGEMENT

Scientific knowledge in coastal management involves using available knowledge, but also being sensitive to uncertainty (O'Riordan *et al.* 2000, Jentoft 2009). Therefore this chapter discusses the tension between knowledge and uncertainty informed by the interviews with researchers. I begin with outlining the probable causes behind sugar kelp decline divided into three categories; the food chain, water properties; and systemic change. Then I will turn to some of the issues that cause uncertainty and debate. After this I will look into the translation of ecological knowledge into management systems, focussing on the issues that the scientists are concerned with. This provides the foundation of the final discussion on managing with uncertainty.

6.1 Causes of sugar kelp decline

The exact causes for the drastic decline in the stock of sugar kelp are unknown. However, with the present knowledge it is possible to detect some plausible reasons for the loss. The figure below is adapted from The Climate and Pollution Agency (2009). The translation to English is mine.

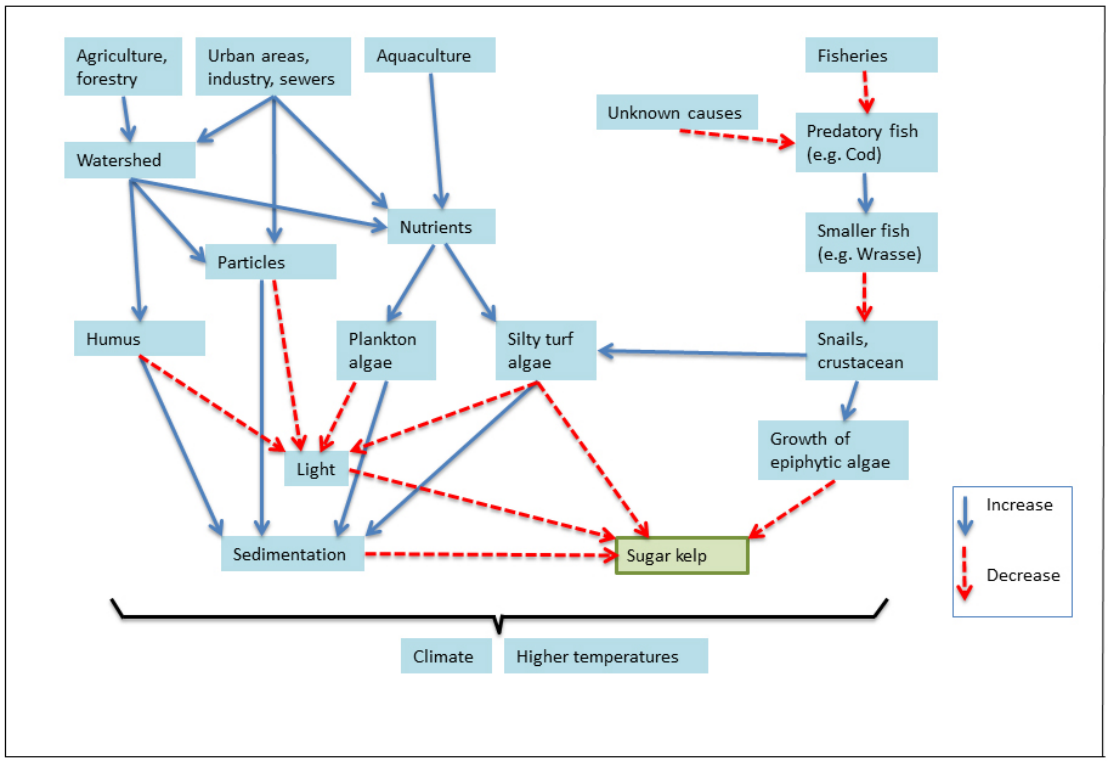


Figure 1: Schematic figure showing possible links between influencing factors and the presence of sugar kelp. Adapted from The Climate and Pollution Agency (2009:20).

Figure 1 shows a selection of factors that is likely to influence the sugar kelp. In order

to make the interpretation of the figure a little easier I will describe the threats organised within two main categories, one regarding the food chain, and one that involves the properties of the water.

6.1.1 Who eats whom?

The right side of Figure 1 above presents a small selection of the food chain likely to influence the conditions for the sugar kelp (*saccharina latissima*). The cod stocks (*gadus morhua*) along the Skagerrak strait have long been under severe pressure (e.g. Fromentin *et al* 1998). Cod is a predatory fish, meaning that it eats smaller fish. When the presence of predatory fish declines, smaller fish, mainly different species of wrasse (*labridae*), are favoured and increase in numbers. Wrasse predates on snails and crustacean and reduces their numbers. Both snails and crustacean are grazers that normally keep the leaves of the sugar kelp clean from epiphytes and other plant species that are competing with sugar kelp (Moy & Christie 2012). As long as epiphytes and filamentous algae are kept in check by grazers, the sugar kelp thrives. With fewer grazers assisting to curb this growth, layers of algae prevents the plant's ability to perform photosynthesis. Photosynthesis is the process where the plant uses sunlight and CO_2 to produce sugar molecules to live and grow from. The sugar is increasingly needed in times of high water temperatures to allow respiration. The hypothesis of over-fishing of cod leading to reductions of macro algae is based on Swedish research, and similar research has not been conducted in the Norwegian part of the Skagerrak (Moy & Christie 2012). In some localities in the Skagerrak the numbers of wrasse are declining due to live capture.[8] This could be a mitigating factor in the over-fishing hypothesis.

6.1.2 Water properties

The left side of Figure 1 deals with another and very complex issue: The change in the water quality as a result of human activities. The three boxes shown to the top left of Figure 1 identifies different types of human activities that have an influence in this regard:

[8] This factor is not part of the model in (The Climate and Pollution Agency 2009). The mariculture on the west coast of Norway are increasingly purchasing live captured wrasse and releasing them in open water cages. The wrasse eats parasites, for instance salmon lice that are attached to the skin of trout and salmon. Some voices argue that this expansive capture may influence the local ecosystems in the Skagerrak. The number of live captured wrasse for this purpose increased from 1 million individuals in 2006 to 11 million in 2011 (The Directorate of Fisheries 2011).

1. *Farming and forestry* influences water quality through contributing to increased runoff. Vegetation keeps the soil in place during rainfalls and ploughing of agricultural land increase the risk for landslides releasing both nutrients and other particles into the water, some of which eventually end up in the sea. Farming contributes to varying levels of highly nutritious runoff depending on the type of agriculture, soil type, winter climate, slope and traits of the watershed. The nutrients of concern are phosphorous or nitrogen from either manure or synthetic fertilizers. In addition there is runoff of toxics from pesticide use (The Climate and Pollution Agency 2009). The influence of forestry is assumed to be relatively low, but some issues need to be addressed, like increased runoff the years following logging, preparation of tracks for vehicles. Issues with forestry will not be elaborated further in this thesis.

2. *Industry and urbanized areas* are sources of wastewater, both from sewers and from runoff during rainfalls. The quality of the services provided by the municipalities for wastewater treatment is varied. The infrastructure for this is quite good in respect to treating wastewater from houses; however, in more remote places households, cabins, and summerhouses are often not connected to the municipal wastewater treatment systems (e.g. Stokke 2004). In addition, the wastewaters from the storm drains are usually released directly into the watersheds. In urban areas where the sewer systems are quite old, the pipes have a number of misconnections leading the surface water from heavy rainfalls to mix with the sewage and the thinned water mass is released directly into the watersheds. This water contains particles and chemicals for example from traffic pollution, as well as nutrition from human waste (two water managers in interview).

3. *Aquaculture* in Norway mainly takes form as mariculture, where the fish are kept inside cages in the open ocean. The fish are fed through the release of fish food, some of which sinks to the bottom and is either eaten by other fish or decomposed by bacteria, leading to oxygen depletion. As there is only a marginal presence of aquaculture in the Skagerrak strait, this issue will not be treated further here.[9]

[9] Further information on the environmental impact of aquaculture on the west coast of Norway can be found in Taranger *et al.* (2010).

All of these anthropogenic causes combined conjugates three main components: nutrients, humus and other particles. These are contributing to eutrophication, non-biological obscuring and sedimentation, all addressed below.

Eutrophication is what occurs when *increased nutrient levels* lead to blooms of phytoplankton (Grant & Jickells 2000). The release of nutrients leads to rapid growth of algae; filamentous algae on the sea floor, epiphytic algae that are attached to the bottom or to plants, as well as unicellular or multicellular phytoplankton living in the water masses. McQuatters-Gollop *et al.* (2009) describe the two problematic aspects of eutrophication. Firstly, increased amounts of plankton obscure the water masses and catch the sunlight before it can reach deeper water. This steals light away from macro algae, like sugar kelp. Secondly, various plankton require different nutrients, and changing the conditions of available nutrients will change the composition of species, thus affecting the food web.

Grant & Jickells (2000) add to these worries the problem of oxygen depletion. When algae and plankton die they sink to lower parts of the water column where they are decomposed by bacteria. This process requires oxygen, and increasing amounts of dead plankton may exceed available oxygen in the water masses, thus leading to anoxic states. This state is mitigated by water exchange; determined by season, water flow, water density, salinity and temperatures.

Humus and *particles* will also obscure the water and let less light through to deeper levels of the water column. Although they are not causing growth of plankton, their presence in the water column leads to non-biological obscuring. In consequence, their increased presence changes the conditions for organisms that require access to solar radiation. Skarbøvik *et al.* (2012) argue that this effect makes particles qualify in their own right as a form of pollution. In addition to this particles transport other pollutants like phosphorous, some metals and organic contaminants.

All of the three components nutrients, humus and particles also cause sedimentation. This happens when the particles or algae sink to the bottom and settle. A high rate of sedimentation makes it harder for the sugar kelp to resettle where it has disappeared:

As previously mentioned, sugar kelp needs to settle on hard surfaces. When there are a lot of silt, sediments, and filamentous algae on the sea floor they prevent the seeds from growing into new plants. This may cause positive feedback: When sugar kelp cannot resettle it is no longer competing over the same nutrients in the water, hence the filamentous algae and phytoplankton take over these resources also and reinforce the new regime.

6.1.3 Systemic change

The threats to the sugar kelp do not stop with loss of predators and increased particles and nutrients. In addition to these factors wider systemic change constitutes risks. In the bottom of Figure 1 global climate change and increased water temperatures are addressed as all-encompassing effects. Notice that there are no arrows here. Figure 1 is complex enough and arrows would have been distorting to the reader of the model.

Moy *et al* (2009) suggest that it was climate change that was a tipping point for a regime shift in 1997 when summer water temperatures were very high. Many consecutive days of temperatures above 19 degrees Celsius is considered dramatic for the alga (Moy *et al* 2009). In order to withstand high temperatures sugar kelp needs more sunlight. The sunlight provides sugar through photosynthesis, a component needed to increase the respiration. As a consequence, a warm day that also happens to be cloudy will suffocate the sugar kelp.

Global climate change can lead to warmer summer temperatures. Thus the two systemic changes shown in the model are interlinked. However, climate change also has other systemic impacts, which may influence other parts of the model. Firstly, the likelihood of extreme weather events, such as heavy rainfall, increases with climate change (IPCC 2012). This increases the runoff into rivers and streams, and carries more sediments than normal levels of rainfall. This further contributes to eutrophication and obscuring as described above. Secondly, global climate change is linked to increased levels of CO_2, not only in the atmosphere, but also in the oceans. CO_2 is water soluble, and already the oceans have absorbed enormous amounts of carbon. This leads to ocean acidification, and already the pH-values have been reduced to 0.1 units lower than pre-industrial levels. Within the end of the century a further 0.3-0.4 units reduction is predicted (IPCC 2007). The most well known

consequence of this is the negative effect on coral reefs (IPCC 2012). However, lower pH-levels also have consequences for growth rate and adult sizes in other calcium dependent organisms, like seashells, snails, crustacean and some species of algae (Bekkby & Eikrem 2012). This systemic change is likely to influence the conditions for sugar kelp as well, considering the important role of snails and crustacean as grazers.

6.2 Sugar kelp decline and uncertainties

Collecting the material to make sense of the case of sugar kelp loss, I ran across several accounts, some of which were contradictory and some with statements of uncertainty. Ecology is a complex field, and making sense of scientific contradictions can be challenging, particularly for decision makers. Contradiction in science is a common phenomenon in all disciplines and uncertainty must be dealt with. However, I did not come across literature that explicitly explained the reasons for the contradictions. After reading many texts and interviewing marine biologists I pieced together what I believe to be a reasonable understanding of the ambiguity. In this section I will address some of the issues that cause contradiction and uncertainty. I will address the various accounts of the exact loss of sugar kelp; discuss the role of cod and possible dual feedback loops; illuminate non-linearity in ecosystem responses; and critique the availability of longitudinal data in research.

6.2.1 Ambiguity regarding estimations of sugar kelp loss

The two informants who were marine biologists gave very similar accounts of the reason for the overestimation of the loss of sugar kelp. They both reported that the current measuring stations are overrepresented in shallow waters. These point sources have a documented loss of 80%, a finding that is certain. The early results from the pilot project in 2004 showed a loss of 90%, and some sources refer to this number. The following years some of the sugar kelp reappeared in the measuring stations, and the number is now estimated to be about 80% with some flux from one year to another. The flux is likely to be contingent with some of the factors mentioned above, like water temperatures in the summer. Another factor are weather events that trigger increased levels of nutrients, for example heavy rainfalls that trigger landslides and increased suspended particles in the water along with heavy release of nutrients. This

will particularly be a problem when weather events occur in agricultural areas so that fertilized soil is eroded.

Precise measurements underwater are incredibly hard to make. There is no possibility of using remote sensing from air - or satellite images, that would be the common methodology for estimating changes in vegetation on land. As well, previous stocks no longer exist making precise comparisons over time difficult. The feasible options that are left is modelling; and calculating stocks on the basis of findings in measuring stations along the coast. This involves site selection: Making the sites representative depends on many geophysical variables like slope, depth, location in relation to water mass shifts from the North Sea and bottom conditions. Regardless of a representative selection, there are other local factors like anthropogenic influence in the area; agricultural runoff levels, distance to rivers and streams carrying pollutants and freshwater, along with the adjacent land use. A selection of sites that would give very high confidence will thus be too expensive and may not be feasible. The option left is modelling of the total areas.

Both of the scientists I spoke to agree that the loss of sugar kelp is likely to be lower in deeper water. One of them explains that the models predict a loss of 60%, which is still a high number. Another uncertainty is the precision of the models. The models use rather crude parameters like slope, wave exposure and depth. There are other factors that play a role, and some of them are likely to be unknown. The 60% estimate is thus unlikely to be correct, but it is likely that it is correct in estimating that the deeper waters have seen a lower loss. A reason for this is the more stable temperatures in deeper water. However, Moy *et al.* (2009) point out that there is a general tendency of water obscuring in the Skagerrak. Obscuring allows less light to penetrate to the deeper parts of the water column, and reduces the liveable depth for benthos algae like sugar kelp. A study from 1991 concludes that the lower growth limit for sugar kelp in the Outer Oslo Fjord was reduced from 25 to 15 meters over a period of 40 years (Rueness & Fredriksen 1991 in Moy *et al.* 2009). This makes the assumption of a lower loss in the deeper water seem ambiguous. However, both scientists pointed out that the water quality in the Skagerrak is improving with reduced release of nutrients from European rivers. This may have reduced the obscuring effect of eutrophication in some localities. Yet the assumption of a reduced

depth occurrence of sugar kelp in the Outer Oslo Fjord is maintained in Moy *et al.* (2009:5) to be between 12 and 15 meters. There is a possibility that this ambiguity in the available research material stems from place specific traits. For example, the overall tendency in deep waters in Skagerrak may divert from the obscuring in the Outer Oslo Fjord.

6.2.2 Dual feedback in the cod – sugar kelp relationship?

Research on the cod stock in the Skagerrak has connected different causes to the decline of cod. Fromentin *et al.* (1998) found that the decline of eelgrass (*zoztera marina*) due to disease in the thirties may have caused the cod stock to decline in this time period. They correlate the survival rate of juveniles with coverage of bottom flora. The study was conducted before the decline of sugar kelp and cannot be linked to this. At present a possibility of a similar effect on cod stocks from sugar kelp decline has not been studied (Moy & Christie 2012). Husa (2007) confirms that there is an assumed importance for cod that sugar kelp remains. Fromentin *et al.* (1998) further say that the juvenile cod predate on snails and crustacean, the same food they will be competing over with the increased stock of wrasse. Presence of bottom vegetation has a double significance for juvenile cod as it reduces risk of predation as well as providing food through its associated animal species (Fromentin *et al.* 1998). Lab-experiments have further proved a correlation between presences of macro-algae and survival rate for juvenile fish (Shoji *et al.* 2009). Reductions in vegetation also involve competition with other species for food and shelter.

The previously mentioned hypothesis of overfishing of cod as one cause of sugar kelp decline together with other theories of cod decline can be interpreted as an outline of a dual positive feedback loop: Firstly, for the sugar kelp as the continued low stock of cod reinforce the negative effects of wrasse predation of grazers. Secondly, for the cod itself as the lack of vegetation may keep the cod stock from recovering. This may be a dual feedback if these effects are proved to reinforce one another. Further research is needed to see if this proposition holds true. A precondition is to verify a link between juvenile cod survival rates and presence of sugar kelp similar to that of eelgrass. I have not found a proposition in the literature that suggests dual feedback. It is a suggestion based on the logic of the two theories combined. About the correlation between sugar kelp and cod one of the marine biologists says:

> "There is no wide understanding of how these things come together in the ecosystem. These are theoretical suggestions that are possible to test in the field."

Further, he explains that there might be a correlation, but that it is hard to decide which way an arrow of correlation should be pointed. It has been debated in academic circles whether this has been steered by the fisheries first, by over-fishing of cod with negative effects for the sugar kelp; or that it might be that if the sugar kelp disappears then so may the cod. Correlation is shown with much more confidence with species like eelgrass, but not yet for sugar kelp. The idea of dual feedback suggests an arrow of causality pointing both ways. Arguably, anthropogenic influence may reduce both and continue in a vicious circle if the cod-system and the sugar kelp-system influence one another negatively.

6.2.3 Non-linearity and research

McQuatters-Gollop *et al.* (2009) state that the new knowledge of marine ecosystems involves recognition of non-linearity in ecosystem responses. The sudden decline of sugar kelp is an example of a non-linear event. However, non-linearity is a very complex issue. It is easier to understand in hindsight than it is to predict. Can research on non-linear events increase our knowledge and contribute to hindering anthropogenic degradation of ecosystems?

Scheffer *et al*. 2012 have through research on complex networks and tipping points found that sudden changes in ecosystems share some traits. Their research revolves around monitoring the natural fluctuations in complex systems. Where systems are likely to have critical thresholds specific changes in fluctuations may indicate the coming of a tipping point and ultimately a systems change. This field of study is still young, but promising. There is an urgent need to accumulate more knowledge on tipping points, regime shifts and ecosystem transitions.

McQuatters-Gollop *et al.* (2009) underline that ecosystem responses are system specific. This makes generalised from model design of ecosystem responses to pressuring factors, like nutrient loads, next to impossible. Predictions of anthropogenic sources are thus difficult. They claim that addressing the state, the actual response in the system, is better developed as a prediction tool. Some of these state indicators will be observable when it is too late, for example measurements of

anoxic bottom conditions. Increased level of phytoplankton in open water is another example of a state indicator that can provide a warning of eutrophication. This is commonly done by measuring the levels of chlorophyll in the water and is among the techniques used in the WFD.

The concept of non-linearity demands a lot from the science. The complexity of this issue involves that there are many pressuring factors and underlying causes. The effect on the ecosystem is a product of how these causes interact within the system. One marine biologist says:

> "Some claim that the sugar kelp disappeared due to warm water temperatures. That might have been the tipping point, but when you balance on the edge of a cliff a tiny degree can be what releases a greater change. It is a more complex picture than just warm water temperatures."

The interviews I had with the scientists left me with the impression that they have a great will to be able to account for complexity and to be able to explore a wider array of issues. One of them explained about the increased research activity in marine biology after an incident of a toxic algae bloom in 1988. The alga *Chrysocromulina polylepis* caused massive fish death and was devastating to the fisheries and aquaculture that year. Thus the government was eager to strengthen the knowledge base, and access to research grants was improved.

6.2.4 Longitudinal research

A central problem to understanding marine ecosystems is the lack of time series in research. One marine biologist explains:

> "You cannot simply look at a location and say 'oh, this looks bad'. Perhaps it has always been that way. You need some data to relate your findings to."

The researcher connected the alga bloom in 1988 to the establishment of the Coastal Monitoring Programme. He indicated that the programme was discontinued in 2011, and he is not happy with this:

> "In my opinion, a wealthy country like Norway that is so dependent on the coast for fisheries and labour, if we cannot afford to maintain time series in monitoring, we are declaring failure. I think it's terribly sad."

The discontinuation of the Coastal Monitoring Programme was confirmed by two sources in NIVA by e-mail. Currently there is a fusion forming a new monitoring programme called ØKOKYST that will start up this year. This programme will continue to collect data from 2 out of 16 monitoring stations from the Coastal Monitoring Programme and 10 out of 16 stations from the Sugar Kelp Monitoring Programme. In addition NIVA will collect samples from 3 of the stations from the coastal monitoring programme to secure data from particularly important time series.

Clearly, the new programme will a have reduced function compared to the two former combined, considering the total of 32 stations being reduced to 12 + 3 stations. Thus, the available data from monitoring will be brought down. Measurements from the Sugar Kelp Monitoring Programme's stations have been conducted every year, so the available data from these will not have holes in the time series, but as these stations are also reduced, some of the point sources will no longer be monitored.

The discontinuation of the Coastal Monitoring Programme causes holes in the time series for the abandoned monitoring stations. Even if future funds allows the work to resume this may cause challenges to scientists due to the abruption in longitudinal data. A further advantage of having coastal monitoring over time is that the accumulated knowledge is based on the same premises and presented coherently. A known problem with different monitoring projects is the possibility of variation in measuring techniques and selected data to be monitored between projects. Scientists meet this challenge when they wish to compare ecological developments over larger distances, for example between countries (e.g. McQuatters-Gollop *et al.* 2009). Data sets from one project to another might be hard to compare when the variables are different. However, the project design of the Coastal Monitoring Programme and the Sugar Kelp Monitoring Programme Sugar make the data comparable.

When I spoke to one scientist I suggested that the reduction of monitoring efforts would break the Norwegian commitment to monitor in the Convention for Biological Diversity. He responded that this would not be the case, as the monitoring would be conducted through other programmes, like the Water Framework Directive and the Norwegian Nature Index. These initiatives are addressed further below.

6.3 Ecology in management systems

In contrast to the Coastal Monitoring Programme or the new ØKOKYST programme the Water Framework Directive (WFD) and the Norwegian Nature Index (NNI) is more part of the bureaucracy. If these are intended to fulfil the role of monitoring biodiversity in Norway it is important to debate how they use scientific knowledge. For this analysis I have chosen to look into the parts of the new structures that my informants are concerned with.

6.3.1 The Water Framework Directive

The WFD is implemented in Norway, but the measure programmes have only started in the piloting sub-districts. A discussion of the specific measures in relation to agriculture will be discussed in the next chapter. Here I will discuss the concerns the scientists I spoke to have about the WFD, and connect them to concerns found in the literature.

The WFD's goal is achieving 'good ecologic status' in all water resources (Skarbøvik *et al.* 2012). Good chemical status is also a goal, but these are just supporting parameters. Further the directive will work to ensure sustainable use of water resources all the way from freshwater bodies to the ocean. This will be done through preventative or improving measures where needed (Vannportalen.no undated3). In Norway the status on this is that all the large river basin districts are established, and the outline of the individual sub-districts within them. The sub-districts that have not yet started the implementation are currently going through an analysis phase to develop local measure programmes. The bureaucracy around this is enormous, and there seems to be considerable efforts in establishing groups and committees to perform the various tasks, and ensure cooperation across levels and between different actors.

The management structure follows a loop: First there is a need for mapping, monitoring performing risk analyses and evaluating the condition of the water bodies. Secondly, based on the first step, is forming a plan where the knowledge base is summarised and with stated goals for water quality. Thirdly, a programme with preventative and improving measures aimed at achieving the environmental goals

from the plan is made. Lastly, these measures will be conducted and monitored to ensure that goals are met. These steps are intended to be repeated in rounds.

One of the scientists I spoke to was concerned about the feasibility of the WFD. How will this be worked with in practice? The ambition in the legislation is obviously high, but the use of biological indicators that is proposed will be very hard to follow up.

> "I wonder who is going to conduct all this work. If one is to use biology to prove changes it requires a lot of knowledge about that ecosystem. There aren't that many marine biologists in Norway. It's supposed to follow all the way from the smallest stream and into the sea. It will require an enormous count of competent people."

The main worry of this informant was that in practice the work is likely to be simplified and thus not fulfil the desirable goals. The other scientist also points to this issue. For example, he says, one such biological indicator can be to control the lower growth limit of kelp[10] on the west coast. An ecological problem over the past 40 years has been that the leaves are eaten by sea urchin. It grows back, but with an impaired ecosystem function. As one marine biologist explains:

> "You can have a kelp forest where the lower growth limit is intact but the stem is devoid of epiphytes so there is no intact ecosystem. Then you would have fulfilled the criteria of the WFD, the lower growth limit is like it should be, but the ecosystem in the kelp forest diverge severely form the natural state. The WFD will not catch this because it has no indicators that look at biodiversity."

He continues to underline that this function is likely to come back over time, yet that it is a problem that the WFD is unlikely to catch this. To actually measure biodiversity require enormous amounts of resources, for example there is a need to use divers to take a look and to send samples to the lab. This type of work that would properly take biodiversity into account would be very expensive. In making the WFD the EU is faced with the challenge of finding streamlined indicators that all of Europe can follow. This also involves making a directive that is not too demanding in order to achieve agreement over the efforts the countries are willing to make. This means that

[10] Not to be confused with sugar kelp: Kelp is *laminara hyperborea*, found on the west coast and in the north.

the WFD is a minimum standard of what all countries can agree to. The same marine biologist continues:

> "It's funny with minimum standards. One is so often content with having done the minimum that one misses that the minimum is not that great."

He underlines that we are free to realise that we can do a greater effort than what he WFD requires. The catch is that we need to think for ourselves if the minimum is good enough. It is politically very challenging for the EU to demand very costly programmes for its member countries, particularly in a time of economic instability.

Another concern I found in the literature was a critical review of measuring practice. Skarbøvik *et al.* (2012) conducted a methodological study of the accuracy of sampling frequencies and load estimation techniques for suspended particulate matter. They found that error rates were very high, even with weekly sampling. Suspended particulate matter is not among the water quality elements that require monitoring in the WFD. They argue that it should be on the grounds that particles are known to transport pollutants like metals, phosphates and organic contaminants. For that reason suspended particulate matter is monitored in many other programmes, like the OSPAR.

Skarbøvik *et al.* (2012) explains that suspended particulate matter is unevenly distributed in water masses as well over time. Heavy rainfalls and events like small or big landslides increase the levels. Also, they point out, all rivers are different, and the best method in one location can be suboptimal another place. There is a need to adapt the frequency of samples and the load estimation techniques for the individual rivers, for example depending on climate and surrounding landscape. An example of such individual traits in river systems, explains an informant from the County Governor in Oslo and Akershus, is the atypical Halden watershed. There, the water quality improves downstream due to high sedimentation rates in shallow lakes. This is backwards from practically any other lowland river. This points to the need for institutional flexibility and adaptation to local needs and issues.

Infrequent sampling is likely to give high error rates. The minimum demand from the WFD is four annual samples for rivers and creeks (Skarbøvik *et al.* 2012). For the

river studied by Skarbøvik *et al.* (2012:468), Numedalslågen, they found that in sampling for mean concentrations of suspended particulate matter "even weekly sampling gave error rates ranging from -50% to +70%". Lower sampling frequencies than this is associated with even higher error rates. If the water management follows the WFD minimum standard only, the sampling frequencies are unlikely to give precise estimates for many river basins. Both possible outcomes of incorrect data are inacceptable: Either an overestimation will demand great efforts in costly measures; or an underestimation indicates that there is no need for action where measures should have been called for.

6.3.2 The Norwegian Nature Index

It seems one of the challenges that are yet to be overcome is the use of definitions that are operable within both natural science and the government. The establishment of the Nature Index for Norway is an example of the policy makers trying to get straight, unambiguous answers to the state of the natural environment. However, if we look into the language and methodology of the natural science there are many answers that are presented without proclaiming definite truth, making unambiguity problematic.

Methodologically the sciences have to express the uncertainty regarding unknown variables. Particularly in a field like ecology, that study very complex systems, there are factors yet to be discovered or defined as relevant in the description of a phenomenon. The data foundations for the findings are usually with weaknesses. This can be due to lack of time series in datasets, unknown variables, and of course the necessity of limiting the variables considered in research.

My impression after speaking to the marine biologists is that they have good reason to believe what they do, but that they acknowledge the weaknesses in their research. With limitations in budgets and feasibility in considering variables one cannot pretend that all is known about the observed phenomenons. The question then is: *How sensitive are the responses in the government to the levels of uncertainty involved in science?* The Directorate for Nature Management use the knowledge of scientists to estimate the state of the selected species for the Nature Index. They ask the scientists to estimate a number between 0 and 1 to define the state of different species (The Directorate for Nature Management 2013).

If we consider this practice up against the level of uncertainty commonly expressed in scientific research we can ask: *Is a number really sufficient to evaluate this state?* When the foundation for these clear answers is ambiguous, how unambiguous can we claim that the number in the Nature Index is? Here we have a system that strives to be unambiguous built upon knowledge that is ambiguous. It is paradoxical, yet understandable from the government's point of view. How can they defend spending money on a number of actions if they express doubt about the foundation of knowledge on the phenomenon? Post-normal science provides a critique to the simplified thinking that the Norwegian Nature Index represents. Funcowitz & Ravetz (2003:2) claim that in complex systems "…there can be no single privileged point of view for measurement, analysis and evaluation". They argue that management based on this thinking will lead to surprise and deviation from expected results. To illustrate this point I have produced an imagined example below.

Consider the sudden loss of sugar kelp that was discovered by chance in 1997. Until this point there was little reason to fear for the sugar kelp. It was seemingly a stable part of the ecosystem in the Skagerrak strait. Suppose that it was the high water temperature in 1997 led to the sudden drop in sugar kelp, and that the eutrophication and following warm summers in 2002 and 2006 that prevented the algae from re-establishing. Imagine a Nature Index for sugar kelp prior to the sudden decline; the number could have been 1 or 0.9, indicating good state and stability. The vulnerability involved in warm water temperatures may have been underestimated in the scientific assessment of the stock. So, regardless of the, here hypothetical, number of the Nature Index, the decline was bound to be unforeseen in the event of three warm summers. The other variables making this picture even more complex is that the other conditions in the Skagerrak strait did not help stabilising and resettling the algae after such a severe death. In this imagined example we can see the weakness of numbering the stability and state of a species. Of course, there is the possibility that the vulnerability assessment from the scientific community would have included the possibility of a decline in the event of warm water temperatures. However, the scientific community seem to have been taken by surprise by the decline that happened, as well as the fact that the reduced stock remained at the same level.

Research on dramatic events like this one tends to come in the aftermath instead of beforehand. Therefore management must appreciate the uncertainty presented in the natural sciences and elsewhere. Complex environmental problems involve levels of uncertainty that we are not likely to overcome with the scientific tools of today, and perhaps this is uncertainty that will always be there. A good response to uncertainty is not presenting the unknown as known.

The variables of the Norwegian Nature Index are operable, but are they true? Perhaps there is room to have an uncertain number approximated to, for instance 0.4, and thereby justify a set of actions. Yet there is a need to keep in mind that the real number might be more or less, or that a number is so one-dimensional that the complexity behind possible threats to species must in one way or another be described more thoroughly elsewhere. To be fair, the Norwegian Nature Index also involves more thorough descriptions of the species and what threatens them, yet the numbering can be said to be problematic. A description of possible threats have the opportunity to be sensitive to complexity, a simple number has not. One scientist says this about the Norwegian Nature Index:

> "In my opinion, it's simplification's absolute extreme. However, what is done along the way is sensible. But this intense need for translating it to a number makes me uncomfortable. Does it mean that if you have a good number and a bad one, does the averaging make it okay? I'm a little concerned in respect to how this will be used."

The quote above points to the potentially bad things with the Norwegian Nature Index, as well as the good things. The exercise of collecting and organising data on biodiversity is definitely important work. However, seen in the light of the discussion above on time series in research, can such a system replace more frequent monitoring? It will be interesting to follow how often a new Nature Index will be produced. It seems more like a project with a potential to be complementary to monitoring, rather than replacing.

6.4 Managing with uncertainty

From the discussions above it becomes clear that coastal management faces many issues of uncertainty. Jentoft (2009: 158) points out that in management there is a need to acknowledge that not all things are known or not-yet-known: Certain things

are simply not possible to know. This warning demands a lot from management systems. The question then is whether this is, and will be, taken onto account in the management of sugar kelp. O'Riordan *et al.* (2000:259) says "uncertainty is not an ogre if it is properly taken into account".

Arguably, the Norwegian Nature Index seem to remove the basic scientific assessment of uncertainty through its use of numbers, thus poorly translating important aspects of science into management systems. The risk of this is to face unforeseen changes in the ecosystem. Similarly, the WFD, although providing clear goals and commitments, risks being only a minimum standard. The implementation of it will be costly, and thus good results are expected. A wealthy country like Norway has the freedom to increase efforts to achieve a management system that is taking complexity into account. It is politically very challenging for the EU to demand costly programmes for its member countries in a time of economic instability, and Norway is one of the few countries in Europe right now with leverage in this sense.

Post Normal Science (PNS) provides an alternative way of thinking on how to cope with issues where uncertainty is inherent, and can prevent the pitfalls of not taking uncertainty into account. In complex environmental problems both decision stakes and uncertainties are high, yet the need for action is urgent. Funcowitz & Ravetz (2003) advocate for stakeholder participation to truly incorporate the web of human values involved in decision-making. Instead of solely relying on expert advice, local stakeholders represent a great potential of innovation in management. Their participation represent a moral judgement of the process as well as ensuring a wider understanding of local stakes and experiences.

Management that simplifies uncertainty and force standards and measuring techniques inappropriate to the localities can become a strait jacket for science. Forcing practices that are incompatible with the ways socio-ecological systems work will not lead to the best results. It is problematic to simply claim that the WFD and the NNI make these mistakes: It depends on how the management is lead in practice. Therefore, a practice that takes in knowledge and uncertainty from the natural sciences, as well as insight of human systems from the social sciences, is necessary.

The discussion above on available and feasible measuring techniques shows some areas of uncertainty. As pointed out by O'Riordan *et al.* (2000) there must be room in the management approach to the unknown, and ambiguity in scientific basis is arguably a source of doubt. But how is ambiguity and uncertainty received by the bureaucrats? One informant in the water area says that in the meeting with politicians and bureaucratic interests he experienced that they actively use scientific uncertainty to legitimize business as usual. As long as there is uncertainty connected to causes, the likelihood of a cause is not enough to take precautionary measures. This is further addressed in the next chapter.

However, if this is a shared experience for scientists, this may put them in a position where they feel a need to downplay uncertainty and use the most negative scenarios in order to send a clear message to managers, politicians and the public. Had the management systems proved reliable to take precaution when met with uncertainty, this would not have been necessary.

Looking to my overarching research question, thus far I can conclude that the challenges that must be faced by Norwegian management of sugar kelp are uncertainty in science on ecological systems. Management frameworks must clarify how bureaucrats and politicians should use uncertainty. In line with the Nature Diversity Act, the precautionary principle ought to be central in weighing interests. The grants for scientific research for supplying management with new knowledge seem to be an area that could be better covered. Public officials would probably argue that the reduction in longitudinal data is compensated for by efforts like the Norwegian Nature Index. Arguably, these types of knowledge accumulations are not comparable: Knowledge collected in bulks cannot replace continuous monitoring, and the monitoring make the foundation for the knowledge that is collected into the NNI in the first place. Thus, the reduction in time series can be said to undermine the very knowledge base the NNI relies on.

Further monitoring will be conducted through the implementation of the WFD. However, the directive has no goal to monitor biological diversity itself, only assess the state of the ecosystems based on a selection of indicators. To see examples of how management address complex problems through the implementation of the WFD the

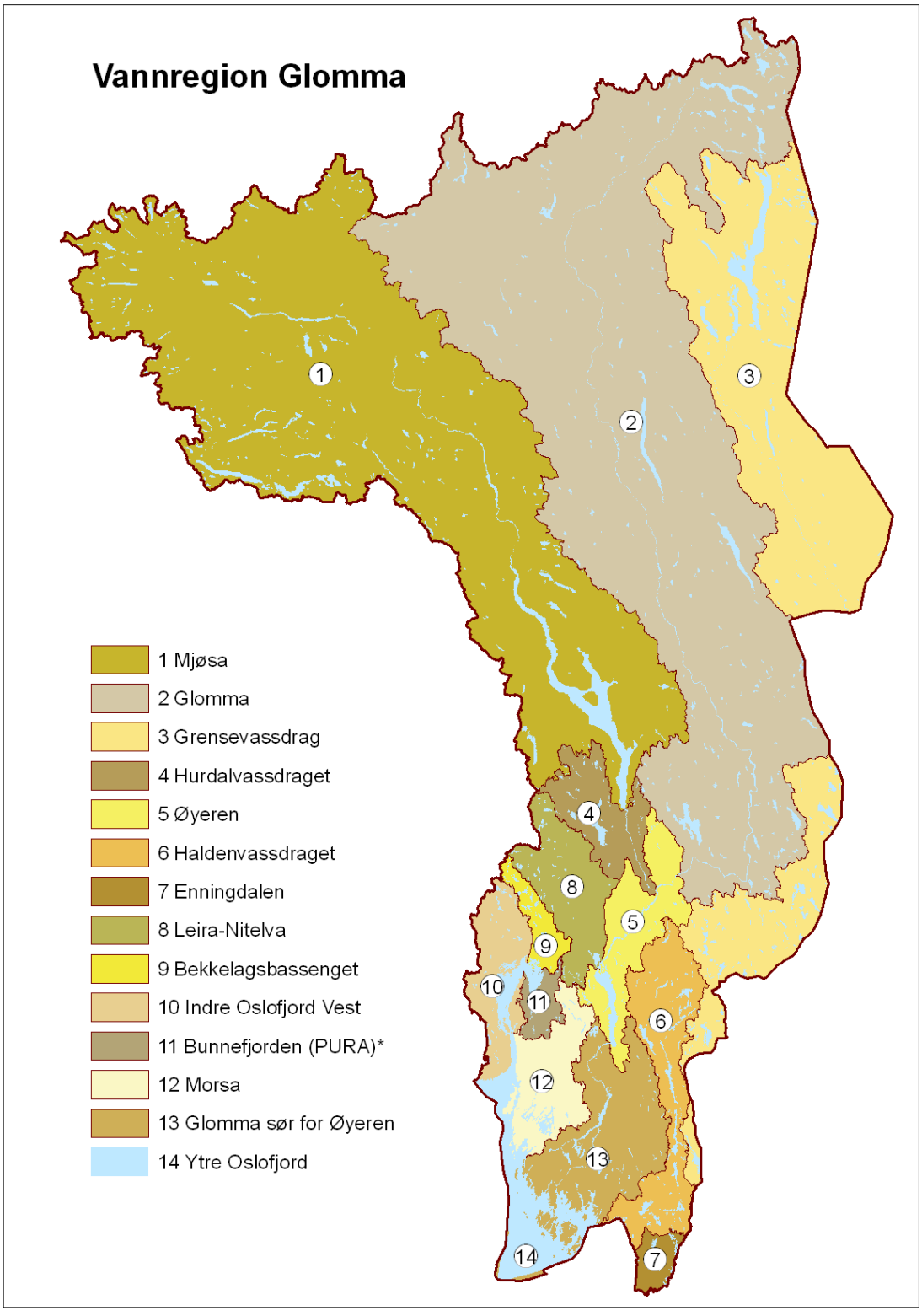
next chapter will focus on water management and agricultural runoff. This discussion will answer the second research question "*How is the runoff from agriculture addressed in the Norwegian implementation of the WFD?"*, and further illuminate challenges for Norwegian water management.

7 WATER MANAGEMENT AND AGRICULTURAL RUNOFF

Arguably, the most important piece of legislation for water management is the implementation of the Water Framework Directive (WFD). As described in the former chapter and in the background chapter, the WFD's goal is to achieve good ecological and chemical status for all water bodies. The WFD is organised so that watersheds are managed together, regardless of administrative boarders. The advantage of this is that institutions within the same watershed must work together. Throughout history there have been many examples of upstream and downstream communities being in conflict over water resources. For example, Rathwell & Peterson (2012) describe conflict between those municipalities in Québec, Canada that rely on ecosystem services for tourism and those that rely on ecosystem services for agriculture. The attempt of the WFD is to address this type of conflict and ensure a holistic management of water systems.

Reducing agricultural runoff is considered crucial in order to reach the targets for water quality in the river basin districts that are connected to the Skagerrak strait and reduce eutrophication (KLIF 2009, The county governor of Oslo and Akershus 2013, The county Governor of Østfold 2009). For this reason it is important to investigate the connection between water management and agriculture. In this chapter I will outline the implementation of the WFD in the Gomma river basin district. I begin by describing the organisation on the regional level. Further I will elaborate on how this district is influenced by the national agricultural policy and describe the tool for environmental policy; the regional environment programme. Then I will move on to look at the implementation in one sub-district. This involves a discussion of conflicts between the local level and the agricultural sector. Lastly I will discuss alternative approaches to systemic change of the agricultural sector in light of wider debates in Europe. The chapter is informed by the perspectives of four informants working within the management system. I will also supply with the perspectives from an informant from an NGO working to promote organic farming.

7.1 Water management in the Glomma river basin district



Map 2: Map of the Glomma river basin district with 14 sub-districts. Adapted from vannportalen.no undated2

The Glomma river basin district is one of three river basin districts that end up in the Skagerrak. The district stretches far into the country, and is located across nine counties and 101 municipalities. Map 2 is adapted from vannportalen.no (undated2) and shows the river basin district divided into the 14 sub-districts. The southern part is dominated by agricultural production of cereals and vegetables, whereas the northern part consists of a more mixed agriculture with a presence of livestock and forestry.

The organisation of implementing the WFD starts with forming a regional river basin management plan that must be approved by the government. This is formed in cooperation among the sector authorities, the counties and the municipalities. These also form a programme of measures based on the overarching river basin management plan. The programme of measures does not need government approval. In the case of discrepancy between the river basin management plan and the programme of measures, only the government approved river basin management plan is valid (The Ministry of the Environment, undated).

The river basin management plan and programme of measures crosses sectorial boundaries. These plans are supposed to be a foundation for all public activity within the river basin district. However, the sectorial institutions are responsible for evaluating the measures connected to their field (The Ministry of the Environment, undated).

On the local level the implementation of measures takes form in the sub-districts that cross municipal borders. Since 2009 eight of 14 sub-districts have started up the implementation. These are called piloting sub-districts. The aim of this has been to start early in the most polluted areas. As well, the experiences from the piloting sub-districts allows learning about the new organisation of water management and have the potential to improve the implementation process elsewhere (The County Governor in Østfold 2009). In 2013 all the other sub-districts will evaluate a programme of measures appropriate for their area, to prepare the implementation. The piloting sub-districts that had an early start have a goal to reach good ecological status within 2015. All the rest that will start up in 2013 have until 2021 to reach their targets (The County Governor in Oslo and Akershus 2013). However, it is likely that some areas will need to extend the time limit for their targets due to either lag of environmental

effects from measures or a lack of feasible measures (The County Governor in Østfold 2009).

7.2 Agriculture in the Glomma river basin district

In previous parts of this thesis the challenges with agricultural runoff have been discussed. How is this addressed in practice? Above, it is mentioned that the sectorial institutions are responsible for evaluating the measures within their field of work. This means that it is the Ministry of Agriculture and Food that is responsible for the evaluation of measures within agriculture. The County Governor is the state's representative in the counties, and thus the food and agriculture department in the county governors office is responsible for this evaluation on a regional level. Every fourth year the County Governor revises the Regional Environment Programme, which is the main tool for implementing environmental policy within the agricultural sector. Below I will outline some general traits of Norwegian agricultural policy and the regional environment programme as a tool for enhancing environmental efforts.

7.2.1 The channelling policy

Over the past 50 years Norway has had a 'channelling policy' that has tried to optimise agricultural practices and increase the total national production of agricultural produce. This policy has been steering the type of agriculture done in the different regions through specifying what type of activities receive subsidies in specific locations. Central justifications for this policy are that it keeps agricultural activity alive in larger areas, and that it makes farming in the periphery feasible. This is a central part of the Norwegian 'district policy' that aims at keeping smaller communities in the districts alive (The Ministry of Agriculture and Food 1999).

There has been a policy to produce cereals and other plant-based products in the lowland landscape in the eastern part of Norway. Livestock production has been encouraged in locations that are steeper or colder (The Ministry of Agriculture and Food 1999). Thus the Norwegian agricultural landscape today can be distinguished between the regions.

The Ministry of Agriculture and Food (1999) admitted that this policy leads to conflicts over environmental concerns. Mainly, they focus on the environmental

consequences of transporting agricultural produce across the country, where products must be carried over large distances. The transport costs would, in fact, be lower if Norway were to import some of the agricultural products from Sweden and Denmark. Further the Ministry mentioned the implications for biodiversity. They argue that keeping up agricultural activity is good for biological diversity connected to agricultural activities. At the same time they admit that monocultures may cause some damage to biological diversity.

The environmental implication that will be further approached in this thesis is the place specific difference in runoff components as a result of the channelling policy. The different regions have varied problems regarding what sort of runoff they produce. Where there are livestock, runoff will contain more phosphorus, whereas fields with cereals and vegetables will have higher levels of nitrogen and pesticides leaching into rivers and streams.

7.2.2 The regional environment programme

The regional environment programme (RMP) is a programme that promotes targeted environmental measures in agriculture. In addition the programme has responsibility to steer development with respect to cultural heritage and landscape. The County, in cooperation with participants from the agricultural sector, develops the RMP. It is rotated nation wide once every four years, allowing for cooperation between counties. The regional environmental programme is the foundation for determining subsidies and is a financial means to promote voluntary environmental measures (The County Governor in Oslo and Akershus 2013).

The framework for the counties' RMP is defined in the National Environment Programme. This programme is developed by the Norwegian Agricultural Authority and specifies which measures that are allowed to use in the RMPs. It also contains specifications of the subsidies that come with the specific measures (The Norwegian Agricultural Authority 2012). Thus, there is a hierarchical structure in the environmental policy within the agricultural sector, and the scientific justification for the measures comes from above. In discussing the role of uncertainty this becomes interesting, and will be followed up below.

Agriculture is exempt from the pollution legislation, thus the means for promoting environmental measures must be voluntary: The farmers receive subsidies on conditions of implementing measures defined in the RMP, meaning that the measures are not compulsory, merely conditions for receiving financial support from the government.

The current regional environment programme for agriculture in Oslo and Akershus was published this year and is valid for the period 2013-2016. I spoke to an informant that worked with this programme in Oslo and Akershus. He explained that the most important issue in the region is to reduce the agricultural runoff, and that 90% of the funds are used on measures related to this. The main measure is to reduce ploughing in autumn in order to leave the soil less exposed to erosion from rain and snowmelt. This measure is relied heavily upon and often leads to conflicts. The specific problems with this measure, and some of the local conflicts over it are outlined below. All farmlands are divided into erosion classes depending on slope. Class 1 is flat, and class 2 is slightly sloping. Class 3 and 4 are considered the most prone to erosion and in order to receive subsidies in Akershus, Oslo and Østfold counties the farmer is prohibited from ploughing class 3 and 4 in autumn.

The informant from the county governor's office told me that they use scientific research as the basis for which measures to reward. The more effect from a measure proved scientifically the higher the subsidy. A challenge for the implementation of measures is uncertainty of the exact environmental outcome. Several of the informants report that one expects a lag in positive environmental outcomes from reduced ploughing.

7.2.3 Problems with reduced ploughing

One source of conflict over the measure of reduced ploughing is the possibility of failed yields. This issue is addressed in several documents. One informant in an NGO promoting organic farming explained the problem for me this way: The reduction of ploughing in autumn leaves the straw on the field over the winter. This increases the presence of *fusarium*, fungi that grow on the grain. *Fusarium* can produce mycotoxins that are poisonous for humans and animals, and available fungicides have shown poor results in tackling this. In addition, the practice of not ploughing has led to an

increased use of the pesticide glyphosate to combat weeds. The increased use of glyphosate is confirmed in the most recent RMP (The County Governor in Oslo and Akershus 2013). The informant from the NGO further underlines that these issues are more complex and that this is just a summary of the issue.

Considering the risk of failed crops it is understandable that this measure is unpopular. An informant from the sub-district further explained that an additional disadvantage is that the soil structure reduces in quality when the ploughing is postponed to the spring, and this may also have a negative influence on yields. As well, when the ploughing is postponed, so is the time of cultivation. Together these downsides to reduced ploughing create resistance among farmers.

7.3 The implementation in the sub-districts

The sub-districts are where the implementation of the measures takes place. These cross municipal borders and the work is coordinated within the district by a project leader. I visited one of the pilot sub-districts that were among the eitht that started up early. It soon became apparent that there was a high level of conflict between the agricultural sector and the municipalities in the sub-district. Below I will outline the general tension and a specific disagreement over a locally decided measure, the so-called 40/60-rule.

7.3.1 General tension

Immediately after I entered the office of the informant in the sub-district our conversation was interrupted by a phone-call. The conversation was quite agitated and I was unsure of whether I was meant to overhear it or not. The informant later reassured me that the conflict is difficult, but public, so my presence was not a problem. The problems they are experiencing are connected to the distribution of tasks and the power to perform them. He explained that their role is limited to advising, but that they have no power to decide what is to be done within the sector.

Due to agricultural runoff being the central cause of poor water quality, this is the sector that they have the most conflict with. The water manager explains:

> "We have no authority. I'm only a secretary, and the sub-district water board is only an advising body: It is the sector authority that is responsible for the measures within

> their field. So if the agricultural sector, that we struggle with here, do not want to implement certain measures, then we cannot do anything, we can only advise them to do so. And in turn we need to report our progress to the EU, so possibly it will become apparent there that the agricultural sector has not conducted enough measures."

From this I understand that the sub-districts are in a difficult position: One the one hand, they have a role that does not include authority; on the other hand they are, at least in part, held responsible for the development within their district. The same informant continues:

> "We know what is required locally to reach the environmental targets: The municipalities need to improve their sewage systems; and we need to reduce a specific amount of input of phosphorous from agriculture. This is what we know, and what we communicate to the different sector authorities: To the municipalities, and to the county governors that have the main responsibility for the measures in agriculture."

Clearly he is unhappy with the way their advice is received upwards in the system. He points to the weighing of interests in the agricultural sector:

> "The county governors do not follow up our advice with requirements. They rely on voluntary action. In addition there are goals of increased output from agriculture and it is supposed to be profitable. Their role is to weigh these concerns, and thus the environment loses."

Not only is this manager's experience that they are not being heard on a regional level. He claims that they have asked the minister of agriculture for a meeting to discuss these issues, but that their request has been declined.

A central problem here is that the informant is opposing to the voluntarily form of the measures. This is a question that must be addressed on a national scale, as this touches upon the exemption from general pollution legislation in the agricultural sector.

7.3.2 The 40/60-rule

The 40/60-rule was a rule that involved the prohibition of autumn ploughing on 60% of areas in all erosion classes within the most polluted sub-districts. The County Governors of Østfold and Oslo and Akershus originally implemented it in the RMP.

However, the farmers' organisations in Akershus opposed it and the county governors finally decided to do away with the rule. It should be noted that autumn ploughing in erosion class 3 and 4, the most exposed areas, remains prohibited.

The central problem is that 70% of the agricultural land in this sub-district is in erosion class 2 (Representative from the county governor's office in interview). Thus, this sub-district has massive erosion problems in spite of a relatively flat agricultural landscape. The local managers from the sub-district and the municipalities feel a need for extra measures that exceeded the ambition of the RMP. The informant in the sub-district tells me that he would suggest no autumn ploughing at all on erosion class 2 in within his area.

However, the sub-region was instructed to discontinue the 40/60 rule by the county governors on the grounds that it was not a targeted measure. In documents, both from the Glomma river basin district and the agriculture authorities, the word targeted is used a lot. The problem is that there seems to be no leeway for local managers to use 'targeted' measures. The local pollution problems are immense, and the available measures do not seem to improve the situation sufficiently. Thus they wish to expand the measures in areas that are not considered important in other locations. Here the problem is that there is discrepancy between the measures defined as sufficient and the local effects. Thus the generalisation of measure effects seems to hinder locally sensitive practice.

This conflict between the sub-district the county governor can be interpreted as an extended conflict with the Ministry of Agriculture and Food. The county governor's role, as previously mentioned is to exercise the policy of the ministries. However, the policy of the different ministries have conflicting goals, but the county governor is bound to speak in 'one voice' as the informant in the sub-district puts it. This predicament is confirmed by the informant in the climate and environment department of the county governor. He reports that the different departments have improved their cooperation over the past years in order to be able to stand behind their decisions collectively. The informant in the sub-district has taken note of this improved coordination. This shows that difficulties between the sectors happen on many levels.

7.3.3 Buffer zones

Another source of disagreement is the practice of creating buffer zones close to water bodies. The legislation prohibits cultivation two meters from the buffer zone. Two of my informants confirm that the national guideline on this is based on the calculated distance from two meters in from the edge of the average water level measured along an overhead line. The weakness of this measuring technique is that if the slope leading to a water body is wide, it will be allowed to cultivate at the very edge where the slope begins and the risk for slides will be high.

Both of the informants points to the alternative approach to this used in Denmark. They explain that the practice have been to calculate the two meters from the top of the ditch, which gives a wider buffer zone that is more efficient in preventing small or big slides from the fields. Last year Denmark even increased the two meters to 10 (retsinformation.dk 2012), causing an outrage in the agricultural sector. The area that is lost in farmlands is equal to 50 000 hectares (Børgesen *et al.* 2009), and is expected to lead to a dramatic improvement in the natural environment.

The informant from the sub-district emphasises that they have suggested increasing the buffer zones for all water bodies in Norway. He denounces that this should be a municipal responsibility, and strongly encourage for this to be regulated by the state.

> "In my opinion it is unnecessary that it is every municipality's task to struggle with this".

Within the municipalities in the sub-district they are now exploring the legal opportunities to extend the buffer zones. A central question is whether they will have to compensate the farmers in order to do so. He reports that the majority of the farmers make this consideration for the environment voluntarily, and without compensation: When they plough, cultivate and harvest, they leave a strip by the edge in order to prevent landslides, regardless of whether the distance is long enough for it to be mandatory. However, there are some that do not, and he is opposed to financially compensating those that have been unsympathetic to the environment.

However, the amount of work put into making local legislation on this is significant. Had the state been willing to change the regulation, the local authorities would have a simpler way of enforcing environmentally sound policy.

7.3.4 Targeted measures

After I had been in the sub-district I spoke to a representative from the climate and environment department in the County Governor of Oslo and Akershus. He further elaborated the rationale behind abolishment of the 40/60-rule. He explained that the central objection to the rule was that it also applied to erosion class 1. Thus the general prohibition of ploughing in 60% of the areas is not targeted to the most important areas for erosion risk. Furthermore it also strikes the areas that are located at a safe distance from the watershed where the measures are not equally important.

The question then is what should be done with erosion class 2. 70% of the agricultural land in the sub-district I visited belongs in class 2. Thus a more targeted prohibition for class 3 and 4 will not help to improve the environment significantly in this area. For this reason the manager in the sub-district expressed a wish for no autumn ploughing in erosion class 2. The agricultural sector and the ministry are very unlikely to agree upon this.

The informant from the climate and environment department underlined the importance of targeting to achieve consensus and improved cooperation with the farmers. As an alternative he suggested that increasing the buffer zones would be a better-suited approach for targeting, along with adapting the measures for areas closer to the watershed. He suggests that the municipalities should work on this in area plans. However, as illustrated above, a range of problems are connected to leaving this task with the municipalities.

Regarding buffer zones, one can expect a wish for financial compensation from the farmers. The municipalities would be the ones responsible for economic compensation if they establish this regulation. Municipal funds are very limited in many places, meaning that some municipalities will be forced to abandon such efforts on the basis of available economic resources. As well, the work to regulate must be conducted everywhere, demanding lots of management resources and time within the

municipalities. A central decision on this may save a significant amount of managerial expenses, but at the same time requires more resources from national budgets.

When it comes to targeting measures for those farms that are closer to the watershed this must be embodied in the RMP. As the manager in the sub-district point out; they have no authority, only an advising role within the framework decided upon at higher levels. Arguing that the focussing should be done locally seems to be inconsistent with the leverage at local levels. For this type of targeting to be feasible, the state and the county levels must contribute with a clearer framework.

It seems that the measures available now are based on simplified factors like slope. In Denmark, the informant from the climate and environment department informs, they use an alternative approach. There they make a phosphorus index, using variables like distance to watershed, classification of stream or ditch connected to it, as well as slope. Together these estimations indicate the importance of erosion from the individual farm, allowing for a more precise targeting.

Perhaps the defence for abandoning the 40/60-rule is just. But where does that leave the prospect for good water quality in this sub-district? More targeted measures seem to be unavailable at the moment, at least as long as there are no restrictions on erosion class 2. The targeted measure of increasing the buffer zone demands a lot from municipalities, and is conflicting with the national goal of increasing agricultural output. On this note the informant from the climate and environment department said:

> "I think we have to realise that in the exposed areas we are unlikely to achieve the national goal of 1% increase in agricultural production. Rather we should try to compensate for those losses in less exposed areas."

Her further emphasises that there is a need to be targeted both within water management and agriculture at the same time. This is important to balance many considerations at the same time, he states. This statement touches upon the issue of conflicting aims in policy. If policy makers are only targeted in their thinking when they think about their own field we are missing an opportunity for a sound policy across several concerns.

7.3.5 *Uncertainty in management*

The informant in the sub-district claimed that the sector evaluation of measures strategically used scientific uncertainty to avoid the most unpopular measures among the farmers.

> "The scientific uncertainty is taken for the benefit of their own views."

This he connected to predefined wishes being dominant in the weighing of concerns, so that the new knowledge is not appropriately considered. The expression of scientific uncertainty leaves room for the policy makers in the agricultural sector to use it as justification for not risking yield losses. The informant also pointed to one specific measure where they gave subsidies in spite of uncertainty. This measure involved the cultivation of grass on areas that were prone to flooding. The scientific grounds for this measure are very uncertain, and the environmental effect of floods represents a hole in scientific knowledge. However, in the RMP the precautionary principle is applied for this measure.

An interpretation of this is that in the agricultural sector, where the stakes are generally high, the willingness to use precaution is higher for measures where the stakes are lower. Thus the application of precaution in total may be unsatisfactory. The RMP as a whole is less exposed for criticism when there are clear examples of the precautionary principle being applied. Thus the sector can more easily get away with avoiding it where the cost or risks of costs are considered too high.

7.4 Alternative approaches to agriculture

There are many competing ideas as to how agriculture should be organised. In this section I will discuss the concept of ecological recycling agriculture. Further, I will outline the findings from this strategy in the Baltic Sea area, and how it is worked with in Norway. I point to the perspectives of my informants on the possibility of a restructuring of Norwegian agriculture. Finally I discuss the findings in light of Norway's role in Europe.

7.4.1 *Ecological recycling agriculture*

An alternative approach to environmental problems from farming is suggested by the promoters of ecological recycling agriculture (ERA), a form of organic farming.

Central to this concept is crop rotations, and the mixed use of agricultural land for livestock, cereal and vegetable farming. The advantage of this method is that crop rotations ensure that the soil maintains optimal quality without the use of synthetic fertilizer and pesticides. Allowing land to rest and regenerate through the cultivation of nitrogen fixing plants like clover also reduces runoff: When a field is covered with clover and not ploughed for some seasons the roots of the plants keeps the soil in place as well as naturally increasing the nitrogen levels (BERAS, undated1). Although technology allows the extraction of nitrogen for the production of synthetic fertilizers from the air, this process is very energy consuming (Brentrup & Pallière 2008). Thus, reducing the use of synthetic fertilizer is also a question of energy consumption.

In Europe 80 per cent of the crops are used as animal fodder, and by replacing cereals for fodder with grazing fields of clover and other nitrogen fixating plants can bind the soil in between crop rotations (BERAS undated1). A precondition for this the co-location of grazing livestock with cereal production. Grazing animals produce manure that helps building of humus in the topsoil. The monoculture promoted today severely reduces the quality of the topsoil. An informant from an NGO promoting organic farming in Norway explains that topsoil is a non-renewable resource. However, he argues that the negative trend of quality reduction can be turned around.

> "Increasing the topsoil quality to a maximum level takes time, perhaps decades, and demands a conscious will to rebuild soil quality through an integration of plant and livestock production."

He further points to research on organic farming that has managed to address the above mentioned problem with mycotoxins: Crop rotations do not leave optimal conditions for the fungi *fusarium*, and thus curbs the growth of it.

7.4.2 Agriculture, a European challenge

Through the literature and the talks I have had with informants it becomes clear that these issues are not unique to Norway. Improved water management is a struggle across all of Europe. One of the informants from the county points to several examples of management practice in Denmark and Germany. He argues that Norwegian implementation of efforts with good results abroad is easier.

Norway, a European country with more financial leeway than most other countries, has the capacity to experiment with new measures. Perhaps the implementation of measures will have unforeseen consequences: They may succeed or fail, but the testing of measures in practice is necessary to widen the pool of feasible options, not just for this country, but for other countries as well. This would be an adaptive response, consistent with the adaptive management framework outlined in the theory chapter. Clearly, the current approach to water management recognises that today's practice is causing environmental problems. Walker & Salt (2006:1) relate adaptive management to resilience, "the ability of a system to absorb disturbance and still retain its basic function and structure".

In the event that Norway would experiment with a large scale restructuring of agricultural practice, those experiences could provide an important foundation for actions in other countries. Environmental degradation from current practice is reaching unacceptable levels all over Europe. With degradation of local environments coupled with negative impacts on the global climate adaptive approaches will become necessary everywhere.

7.5 *BERAS Implementation*

The Baltic Sea, that has water mass exchange with Skagerrak, has long been under pressure from agriculture. There is a very low level of shift in water masses in the Baltic, which leaves the area vulnerable to accumulated nutrients from agriculture. The Baltic has a long history of eutrophication (McQuatters-Gollop *et al.* 2009).

The Baltic Ecological Recycling Agriculture and Society (BERAS) is a transnational project for countries surrounding the Baltic Sea. The project is partly financed by The European Union and Norway, and the goal is to develop alternative agricultural practices that reduce runoff. BERAS has put considerable research into evaluating the environmental impacts of implementing ecological recycling agriculture. Their key findings are that it will reduce climate impacts from agriculture and improve the poor condition of the Baltic through reducing runoff of nutrients (BERAS undated2).

The informant from the NGO promoting organic farming follows the BERAS implementation closely. He participated in a BERAS conference in Tallinn in February 2013. The community of people connected to this project all report the same challenge: Implementation in the different countries is really hard. There is a wide agreement that this method would significantly improve the environmental state in the Baltic, but restructuring the established agricultural practice is an enormous project.

> "At the conference it was pointed out that it was difficult to gain support for this solution in the countries surrounding the Baltic Sea. Advocates for ERA do not constitute a group large enough to have sufficient influence on the future agriculture."

The future development of ERA will be interesting to follow. In recent years interest for organic farming has escalated in Europe, increasing demand (The Ministry of Agriculture and Food 2009). Perhaps this can strengthen the position of ERA in the future agricultural policy.

7.5.1 Norwegian assessment of ERA

Norway is participating in the BERAS implementation as an external collaborator. From the public sector this is done through a project leader from the County Governor in Oslo and Akershus. His job is to assess the possibility of implementing the ERA method in pilot farms in the Oslo fjord region, meaning Telemark, Vestfold, Buskerud, Oslo, Akershus and Østfold.

He explains that the Norwegian meat production today is reliant on supplies of soybeans from Brazil. He further argues that grazing livestock has the potential of being the most environmentally friendly meat we can produce, due to their ability of utilizing grass and clover for food: Resources that humans do not consume. In contrast, pig and poultry eats grains that could have been consumed by humans, and in today's practice so do cattle.

If grazing is increased, livestock in Norway has the potential of being far more environmentally friendly than it is today. He stresses that grazing increases the humus in the topsoil, a property that synthetic fertilizers do not share. In a long-term perspective alternatives to current practice will be necessary to evaluate as the global

phosphorous resources are running out. He says estimations vary between 15 and 25 more years before these reserves are empty.

7.5.2 Norwegian implementation of ERA

The informant from the NGO stresses that an implementation of ERA in Norway demands a massive change in agricultural policy, whereby livestock and cereal production must be localised together. Considering the description of the current channelling policy above this development would be the opposite strategy of what has been the policy for half a century. Needless to say, asking for a change of such proportions meet resistance within the system.

> "In order to achieve such a change one must have the support of politicians on all levels, in addition to an endorsement from the bureaucracy that is connected to agriculture. Although we have research and numbers that shows the positive environmental effects of ecological recycling agriculture we are in no way at the end of the road."

The informant from the NGO further claims that not approaching this on a systemic level the agricultural policy fails at solving the problems on a long term. The approach to the problems caused by the channelling policy is to look at one problem at a time, like the above-mentioned problem of reducing runoff through reducing autumn ploughing.

> "[the example of mycotoxins] exemplifies that treating only the symptoms gives new unforeseen problems as long as the underlying causes are not identified and solved".

The informant from the sub-district claims that the channelling policy is untouchable in the political climate today. Therefore it is unlikely that there will be a massive change in the direction of ERA in the near future. A central challenge, he says, is to make organic and environmentally friendly agriculture profitable enough for farmers.

The informant in the sub-district pointed out that most farmers in the east of Norway have full time jobs next to their farm. The production of cereals does generally not require full time labour. However, livestock require this, and this is the reason that the channelling policy is so closely connected to the district policy, aiming at allowing fulltime employment for people in more peripheral districts. There is generally a

lower level of interest for full-time farming in the east. However, solutions in the east that involves livestock could take on many forms.

For example, one cattle farm can be run fulltime and lease property from neighbouring farms for grazing. Ownership can also take the form of a shared farm where the work is part time and in shifts. If several ownership and operational models are tested and evaluated, the knowledge base for feasible options can be enhanced. This is beneficial for countries that need a similar restructuring, but have less financial leeway to experiment.

7.6 Conflicts over agriculture in water management

From the discussions above, there are some recurring categories of conflicts. Here I will outline conflict between sectors and levels.

7.6.1 Conflicting sectors

A recurring theme in my material is the challenges of balancing conflicting interests. In this respect there seems to be too weak bonds between the sectors to identify the conflicting factors and *cooperate* to overcome the problems and finding agreeable solutions.

Clearly, a weakness in the management of agriculture is that the measures are decided in cooperation with the sector authorities and the farmers together, with limited participation from other fields. This is the type of stakeholder participation that Brugere (2006) suggests works better on the grounds of homogeneity among the participants. However, it is not the model of stakeholder participation that in accordance with post-normal science and adaptive management theory will lead to innovative solutions. Since agricultural aims so often conflict with environmental goals, representatives from the latter should also be invited to into the evaluation process for measures. This type of cooperation is supposed to make the sector aware of the stakes in other sectors and encourage new solutions. Currently it is just tug of war where the sectors pull in opposite directions.

In working with this thesis I spoke to the son of a farmer who explained that his father always ploughed horizontally in sloping fields. He did this to prevent the humus from

eroding: the snow, ice and water between the rows would largely remain put. I contacted the agriculture and food department at the county governor of Oslo and Akershus to ask if they had considered this measure in the RMP. They said that it had been discussed, but that it had not been included. They further reported that there was research being done on it, which eventually could be used in guiding material for farmers.

It may not be cost efficient enough to be included in the RMP. However, this is the sort of suggestion that local stakeholders can agree on in an adaptive management process. It is an example of a simple idea and an innovation that is based on the tacit knowledge that local stakeholders have. One cannot be sure that it works, but the experimentation represents no extra cost for the farmer. Therefore, it if works it is a win-win solution for farmers and water managers, if it has no effect, nothing is lost. As opposed to taking the conflict up a level, this could have been part of a local experimentation process to learn, adapt and improve local techniques. Reflected in wider frameworks, like the Aichi Targets outlined in chapter three, is the assumption that implementation will be enhanced when there is room for participatory planning. It builds capacity and anchors the value of the efforts at local levels.

Another thing I have noted is that lack of a debate that revolves around conflicting interests between fisheries and agriculture. Through the conversations I have had with people in water management this theme has been invisible. Had I visited a sub-district with marine borders, this may have been different. Arguably, the fisheries sector has high stakes in the structures in agricultural policy and the environmental goals there. These are in fact two economic interests in state policy that oppose one another, and the environmental policy is a bridge between them.

7.6.2 Conflicting levels

Regarding the discrepancy between the different levels it is problematic to generalize. I have found examples through interviews, but I have no grounds to say that this type of tension is common between the sub-districts and the river basin districts in general.

Schultz *et al.* (2010) say that stakeholder participation cuts across either levels or sectors. The only stakeholder participation relationship I encountered through

interviews is the one that cuts across levels of public management. The examples I have come across seem to present some central challenges. From the general level of tension between the sub-district and the Ministry of the Environment, practiced through the County Governor, a central feature must be addressed. The likelihood of successful participation is not high, when the parties feel that they are not heard.

The sub-district relied on the 40/60-rule on to come closer to their environmental target. The discontinuation of it is justified above, but there seems to be no compromise, no other alternative in return. The representative from the County Governor's climate and environment department promoted targeting. However, this could have been addressed through enforcing the 40/60 rule on erosion class 2 only, thus avoiding the problem of involving class 1. The central problem here is the lack of cooperation between the levels. Had the participation across the levels been stronger, the manager in the sub-district could have been in a dialogue over alternatives to the rule. Instead he expresses frustration over being stuck in an advisory role without authority. Through participation and compromises the need for authority at sub-district levels would perhaps not be needed.

The problem of the sub-district feeling unheard does not stop with limited participation at the county level. Additionally, the sub-district and its municipalities asked for a meeting with the Minister, and were declined. This reinforces the lack of trust to the higher levels, and trust is a core trait in successful stakeholder participation.

7.6.3 Where levels and sectors meet

Traditionally a recurring political debate revolves around the tension between municipal and state funds. The conflict of buffer zones mentioned above applies to this type of conflict. Where the state delegates tasks to municipalities feasibility must be accounted for to achieve the best results. The state can provide support to municipalities in two main ways. The first is to make legislation that gives the municipalities or sub-districts the right to enforce restrictions. The second is to provide funds for compensation where the losses are great for the farm, individual or company.

One of the informants from the county governor's office says that to achieve a faster pace in improving the environmental state the balancing of legal and volunteer frameworks must be considered.

> "The time is over-ripe to discuss the general exemption from the pollution legislation in agriculture."

This type of concern seems to span across the levels and sectors. The call for revising pollution legislation is shared by the informant in the sub-district and representatives on the county governor level. The informant in the sub-districts expresses frustration over agriculture being the only industry where the measures are based purely on voluntary action. This is very challenging when this particular sector is the main source for eutrophication in the local water bodies.

Another problem with the RMP, one of the representatives from the county says, is that the funds are not predictable over time. If the government changes by the next election, the funds for environmental measures in agriculture can be cut. This is both frustrating for farmers, as well as water managers. Debates over whether voluntary measures are the only ones that agricultural sector should use also depends on the political climate.

7.7 Room for improvements

Agriculture is a central sector in water management, and there are many concerns regarding the way the sector integrate environmental goals. The likelihood of identifying win-win solutions is higher with improved cooperation between agriculture and other sectors. The sector-wise approach to evaluating measures may impair the opportunity of cross-sectorial management that is necessary for adaptive management in socio-ecological systems. There are many considerations to take into account and the individual sector is not suited to see all the stakes outside their own field, yet their practice have consequences far beyond the locations of the farms.

Water management in river basin districts and sub-districts have a goal to connect the measures and practices with central goals. This is supposed to secure a holistic approach. The conflicts revealed show some serious challenges for successful stakeholder participation across levels and sectors. Thus, the practice is not coherent

with adaptive management. Anchoring the projects through local needs seems to be challenging in the sub-district I visited, particularly in the situation of very impaired ecological states, and high levels of conflict.

In the sub-districts further investigation is needed into two main issues. Firstly, exploring how the local farmers and management can work together, and secondly how to enhance the cooperation between the County Governor and the sub-district when there are conflicting goals involved.

On the state level there is a need to take in water management considerations in revising current policy. Central issues include revising the channelling policy and looking at alternative agricultural practices that involves moving some of the livestock to the east. Central issues also involve re-evaluating the extent of the exemption from pollution legislation in agriculture. Finally there is an urgent need to increase the buffer zones surrounding water bodies. This last point is likely to cause a lot of conflict, and leaving that task to the municipalities is unlikely to give equal results among municipalities and sub-districts.

8 MANAGEMENT IN PRACTICE

Managing complex environmental issues require consideration for many things at once. Socio-ecological systems consist of socially constructed sectors and fields. Currently global environmental problems threaten the sustainability of these systems. The solution lies in synthesising knowledge and making decisions in spite of uncertainty. Thus far, complexity of the ecosystems has been addressed, along with the way uncertainty is treated in science and management. As well, examples from the implementation of the WFD have provided some insight to challenges for management.

In this chapter I will synthesise the discussion from the two former chapters to provide an analysis of the challenges with managing sugar kelp. I will begin by addressing the government policy on coastal management. Next, I will discuss the practice of new management paradigms, and the anchoring of policy in the public. Lastly, I will discuss some of the scientific recommendations for addressing sugar kelp loss and see how these can fit into integrated coastal zone management.

8.1 Holistic management of Norwegian coasts

In April 2013, the Norwegian government published a management plan called 'Holistic management of the marine environment in the North Sea and the Skagerrak' (The Ministry of the Environment 2013. My translation of title). The plan aims at providing a framework for sustainable management for resources and ecosystem services. The management approaches promoted in this plan are holistic and ecosystem based management.

The management plan recognises that there are some ecosystem services that are provided in the ocean that are not applicable to economic pricing. The services pointed to are regulating and supporting services. One of the aims in the plan is for these services to be weighed in prioritisation of marine resource use to ensure sustainability. This is good news for sugar kelp, as the services provided by that ecosystem apply to this. The loss of sugar kelp is also mentioned several places in the plan.

Further there is weight on coordination between sectors and providing predictable management that allows the coexistence of industries. Coordination of sectors is very important for holistic management. However, the sectors that are included in the plan are mainly those with activity located directly in the sea. Agriculture, that is central to this thesis, is of course mentioned as a diffuse source of pollution, meaning that it is a source from large areas in contrast to point sources. However, the involvement of agricultural authorities and research could have benefited a better integration of these sectors. From the previous chapter it is clear that agriculture to some extent is isolated from other sectors in deciding environmental measures.

The management plan is mainly intended to cover marine open waters outside of the baseline, meaning that most coastal activities are only included as external factors, for example aquaculture that is a great source of pollution on the west coast of Norway. The same goes for land-bound activities, like agriculture. Regardless, central conclusions are that the marine ecology is influenced by these external factors, thus there are implications for other sectors. Although these implications are crucial for holistic management, it is hard to predict how it will be received in the other end. The goal in the plan that applies to agriculture is cited below.

> "Anthropogenic contribution of nutrients, sedimentation and organic material shall be limited so that significant negative impacts on biological diversity and ecosystems in the management plan area is avoided." (The Ministry of the Environment 2013:125. My translation.)

The other goals summarised in the plan are equally short and general. Further the government states that they will:

> "Follow up relevant measures in water management plans connected to the The Water Regulation[11] to reduce environmental problems arising from the impact on coastal and marine environments of national emissions of pollutants, nutrients and particles." (The Ministry of the Environment 2013:130. My translation.)

This shows that they are connecting relevant dots in this document: The connection between the WFD and the marine environment is fundamental. However, they are

[11] As mentioned in the background The Water Regulation is the integration of the WFD in Norwegian legislation.

mentioned here as external factors, as the scope for this management plan is to apply to open waters. The question then, is whether the holistic view here corresponds with an equally holistic view in other locations in order to make an overlap of consideration for external factors. For an integrated management this document alone is not good enough unless it is received in the other end, and becomes part of an equal aim for holistic management in other sectors. On the grounds of the last chapter the agricultural sector can hardly be said to be holistic in its environmental approach.

One of the scientists that I interviewed said:

> "One uses several years just to legislate the stop of biodiversity loss. It must be simpler to enact this than to actually do it."

The same concern may apply to this plan. Comparing this management plan to the ambitious goals of the WFD, examples provided in this thesis shows that it is in the implementation that the difficulties occur. Looking back, there are many examples of ambitious goals that have not been met. For instance, Norway supported the United Nations Millennium Development Goals, where goal number seven was to reduce biodiversity loss significantly by 2010 (FN-sambandet 2012). Just because this was stated in a plan does not mean that it was going to happen. Ambitious goals are important, but it is only when they are integrated into action and implemented that they make a change. Thus the integration of holistic goals into the management framework at all levels is crucial.

8.2 Practicing new management paradigms

Management paradigms set the framework for the governing of resources, and the management plan for the North Sea and the Skagerrak promotes holistic planning. A holistic approach is sensible, especially in dealing with environments where stakes are high. However, how is the management paradigm translated into practice?

Storbjörk & Hedrén (2013) found that the implementation of integrated coastal zone management (ICZM) in a small coastal town in Sweden showed divergence between stated goals and practice. The community had great problems with erosion of sandbanks with damages to human developments. Expert advice suggested that instead of promoting hard protection measures, one had to work with nature and allow

erosion to happen naturally. Instead of implementing hard measures that are intrusive to the natural environment, decisions on locations for developments must be altered. The expert advice was proposed already in the 1980's, but not until 2004 did managers implement this into their plans. However, management showed a lack of horizontal integration on the municipal level. The different sectors did not cooperate on the matter. Within civil society there was disagreement over whose behalf the management of erosion should be done, private landowners or the general public. These conflicts were not explicitly addressed in the management. Citizens of the town described the process as 'a one-man-show', where one municipal planner made all the decisions and did not cooperate with local managers and stakeholders across sectors. Not only is this against the basic principles of adaptive management and ICZM, it is also an example of a manager not adapting his or her idea of appropriate management approaches into the management framework expressed in the policy. In addition to the local problems, the vertical predictability was poor: The signals from the government on appropriate coastal management were inconsistent over time, making local policy prioritisations harder.

Storbjörk & Hedrén (2013) argue that sustainable policy is commonly framed in a way that makes integration of social, economic and environmental concerns seem simple. In reality this integration is very hard, thus it must be properly accounted for in management frameworks.

Similar challenges are likely to be experienced in Norway as well. Already there is a great level of conflict in the coastal zone over property rights and public access. The assumption of the public speaking in one voice is one that must be addressed. ICZM attempts to meet these challenges, and was in the Swedish example supposedly the framework applied. Nonetheless, the conflicts that arose in that local community show that the managers did not apply the framework in practice. This is the challenge with using fashionable labels on management approaches, like the marine management plan above uses the terms holistic and ecosystem based planning. These terms are likely to continue to be applied in the future, but how will it be ensured that the framework is actually applied?

Tuvendal & Elmquist (2011) point out the importance of recognizing that the direct benefits to humans from ecosystems often spring out from ecosystem services that are distant in time and space. For example, the ecological functions required to provide the sea with fish take place on a wider scale than the location of the fisheries. This creates a challenge in management where the locations of the beneficiaries are distant in time or space from the ecosystem that must be managed sustainably. This very distance may be the reason that makes the management of agriculture and the Skagerrak coast so disconnected. Part of the required action needed to safeguard coastal resources must be conducted by farmers that may not see themselves as the beneficiaries. They are only stakeholders in the sense that the management framework may impose inconvenient regulations and limit their yields. This distance makes the management process difficult, and it is hard to find common ground and agreement on acceptable goals.

In this context, the weakness with the new plan 'Holistic management of the marine environment in the North Sea and the Skagerrak' is that many of the factors that have a negative influence on the marine environments are external to the scope of the plan. Improvements in agricultural environmental measures represent a benefit for marine environments. For agriculture, marine issues will only represent limitations and detriments. With agriculture that mainly seeks increased production, changed practice represents an obstacle. How then can the holistic approach translate the benefits of the ecosystem approach into agriculture? Perhaps the solution can be an integration of wider societal stakes through designing management plans for the *food system*. Then the Ministry of Fisheries and Coastal Affairs and the Ministry for Agriculture and Food would have a shared responsibility of looking at the food production system holistically. Through such cooperation the stakes for Norwegian fisheries will be thoroughly considered in the policy, and the frameworks for ecosystem approaches that must be followed further down in the hierarchy will be based on wider stakes. When increased agricultural output compromises the output in fisheries then there is no holistic approach, and this is where we stand today. The fact that the WFD management delegates the responsibility of assessment of environmental measures to the separate sectors is contrasting with the concept of holistic management.

8.3 Public support of environmental policy

Intrinsic to environmental policy is the public support that politicians can rely on. Thus, public understanding of environmental constraints is important, as well as public understanding of science. Here I will outline some of the issues regarding communication of science to the public and managers. I will also look at the role of human values in support for environmental policy, and address change in expectations to ecosystems in time and space.

8.3.1 Communicating science

Ricketts (2009) claims that one of the greatest barriers to helping integrated coastal management to be politically prioritised lies within the scientific communities failure in communicating in clear terms what issues we are facing. This makes the information available to politicians and the public weak and filled with academic language that means nothing if you are not a scientist. Knowledge transfer is a concept that is brought up a lot in environmental issues. Through the conversations I have had with scientists doing research in the field the real problems have become clearer to me. In advance of the interviews I had read a lot about sugar kelp, and also about eelgrass and kelp. The problems were clear to me and I had a pretty good idea about what sort of issues that needed to be addressed in order to improve the situation. However, when I spoke to the scientists they expressed uncertainty, and the sort of methodological scepticism that any good scientist will do in order to avoid jumping to conclusions. Within academia this is a healthy sign, and it is the sort of attitude that prevents scientist from making errors. Indications of a connection of causes does not mean that there is definite proof for these connections, and further research and monitoring over time is necessary in order to put the theories of these connections to the test. There are not always resources to conduct this work over time, and the scientists can thus be prevented for proving connections that they very well could have been able to observe had their resources not been restricted.

Many people in the public, as well as managers and politicians may have unrealistic expectations to the level of confidence of the theories on sugar kelp and the loss of it. Ricketts' call for clear, simple, and un-ambivalent statements from scientists, in order to make the issues and the necessary action clear to the public, put these scientist's reputation and careers at risk. The kind of language with simplistic communication of

scientific knowledge in popular science is not in high esteem in academia. This leaves a choice in the debate on communication of science: Should academic circles approach the public with clearly stated messages founded in knowledge with uncertainties? This would require agreement among scientists to not discredit one another for simplifying messages. Alternatively, scientists can continue to insist on being able to use the same complicated language to express uncertainty in science to the public.

Ricketts (2009) makes his proposal of clearly stated messages from scientists to his fellow academics within the field of marine biology. I would like to add to it by expanding the focus to the interdisciplinary scene. Although issue of sugar kelp loss is observed and understood by marine biologists, they are not representatives of a field that will handle this issue in its entirety. Global and local environmental problems are intrinsically interdisciplinary due to the organisation of politics, administration, knowledge production and civil society. The issue of communication urgency is neither limited to one field within biology, nor to academic circles alone. It is an issue that concerns people across these groups. Ricketts call for increased participation in public debate as well as more frequent statements from scientific gatherings, like conventions and conferences, in order to draw attention to the issues more frequently.

In the eye of the public expressions of uncertainty discourages actions. Like we see with the issue of climate change and the debate regarding its anthropogenic nature, all expressions of uncertainty is used as ammunition by opposing forces, and legitimizes the postponing of action. Environmental problems that involve tipping-points are so rapid, so dramatic, and so sudden, that it requires action, even when there is still uncertainty regarding the exact causes. It is possible to identify a problem and start mitigating some of the most probable causes, while still conducting research in order to understand the whole phenomenon in detail. In fact, sometimes action long before this stage of complete understanding is necessary in order to prevent worst-case scenarios.

8.3.2 The role of civil society in ICZM

Post-normal science suggests taking action before certainty in order to act precautionary (Funtowicz & Ravetz 2003). Jentoft (2009) add to this by stating that

not all things can be known. By postponing of mitigating action due to uncertainty socio-ecological systems are not building resilience. The risk of this is to suffer the consequences, and *then* take action. In neither approaches, taking early action or not, is there a guarantee that the mitigation will lead to an ecosystem state similar to the previous one. The distinction is that the chance for a better outcome is greater with early action. In addition the alertness to change is greater when action is taken. This builds adaptive capacity.

Jentoft (2009) claims that there must be some level of self-governance in order to build adaptive capacity. A reason for this is that conflict resolution on local levels is harder to address without some leeway. Conflicts may occur that do not correspond to instructions from above. In the previous chapter the conflicts between the sub-district and the agricultural sector is an example of this. The decision-making is taking place one or two levels up in the system; on the county governor level or on the ministry level in cooperation with farmers organisations. Thus the influence of local management is excluded. Had the management framework corresponded to adaptive co-management, the framework ICZM falls in under, the conflict would have been addressed locally.

Arguably, the conflict level escalates when the conflict is treated as a power struggle, as opposed to collaboration over locally adapted solutions. To build adaptive capacity the local learning process is crucial, and learning does not come from above. Jentoft (2009:163) argues that learning is empowering and leads to a "mutually reinforcing process". This empowerment is crucial in order to anchor the management and build a common value system among stakeholders, where participants feel responsibility and inclusion. The example in the previous chapter of the farmer who ploughed sloping land horizontally is one such example of tacit knowledge on the individual level. Stakeholders have a huge knowledge base, and utilising that in management is essential to adaptive management.

8.3.3 Human values and changed expectations to ecosystem services

At all times, humans have exploited natural resources, and practice over time creates expectations of what the environment provides. Castree (2001) point out that the value judgements of nature are embedded in the social practice, for example

technology and culture that determine how nature is utilised by humans. Feedback in socio-ecological systems causes both nature and society to change, not only in physical form, but also in human values, expectations and cultures. Mee *et al.* (2008) explains that as the human assessment of the state of nature is changed in time and space. When the conditions in the environment are changed and the availability of a specific resources decline expectations to the qualities and quality of ecosystems are reduced.

As an example from the United Kingdom Mee *et al.* (2008) point to the expectation of cod catch in the North Sea. The year of 1998 saw a slight increase in catch and was considered a good year. However, compared to data from the seventies 1998 had a lower capture than the 'bad' year of 1977. Overall, the seventies had enormous harvesting of cod, and the decline in 1977 sent a shockwave through the fisheries. However, the catch continued to decline, and over the course of 11 years the expectations to availability of cod had changed radically. So much had the expectations changed that the slight increase in 1998 was even used to justify continued fishing while the International Commission for the Exploration of the Sea recommended a quota of zero to allow repopulation of the cod stock.

The example demonstrates that the expectations to ecosystem services can change over the course of a decade. When the positive development in 1998 was used politically to justify continued capture two understandings can explain this: Either it is another example of using knowledge strategically to work towards a predefined goal. This suggestion implies the active exercise of sticking ones head into the sand and strategically avoid the use of long-term trends to evaluate the state of the cod stocks. It may be an expression of wishing for it to be true that the cod stock can re-establish themselves without changed human practice. An alternative interpretation is that the expectations to ecosystem services have been reduced so severely that any increase is unquestioned as good news. The human values of expectations become integrated with policy and management.

Human values as a part of the environmental policy equation is normally ignored. The point of Mee *et al.* (2008) is to demonstrate that expectations are not fixed, thus they

must be accounted for, particularly when ecosystems change, because the human expectations may have changed with it.

Mee *et al.* (2008) further point to the 'Eurobarometer' survey made by the European Commission in 2005. This survey asked statistically comparable population samples in Europe to rate their environmental concerns among a selection of 15 environmental problems. All across Europe people responded that water pollution was their main concern. However, natural resource depletion and biodiversity loss was on average rated on 9th and 11th place respectively. This finding may indicate that in terms of deciding what is most important, people do not necessarily link environmental concerns together. As we have seen in the two former analysis chapters the link between water pollution and biodiversity loss is clear. The survey may witness of poor communication of scientific research into the population. The fact that the public concern for water pollution seems to be disconnected from concerns for resource depletion and loss of biodiversity may have grave implications for policy pressure.

Knowledge on values systems thus becomes important for management. Here, the social sciences and the humanities can contribute to making human values accounted for.

8.3.4 Reaping the surplus, a principle already agreed upon

Complex environmental problems seem to share a central trait: Tackling them often requires a change of human behaviour and changes across several institutions. The demand for change is often seen as a threat to growth, at least in the short term. Therefore the requested changes are also controversial: How can reduction of growth be justified if the measures involve uncertainty of the effect on the environmental problem? The possibility that the strategy is not good enough, or that the problem at hand still will remain due to other causes, reduces the willingness to sacrifice growth. Political controversy makes efforts half hearted or slow and with little or no effect. However, there is another way of looking at it: I believe that the principle of precaution and of sustainability is a principle that most people agree on already, not only in theory but in practice. Consider the following example:

Revenues from the petroleum industry have resulted in a considerable investment in the Government Pension Fund of Norway since 1990 (NBIM 2011). It is commonly referred to as the oil fund, and is one of the world's biggest investors (BBC News 2013). Approximately 1 % of the worlds equity markets are held in the Norwegian oil fund.

The policy of the oil fund is disputed, however one principle is widely agreed upon: The budgetary rule, known in Norwegian as *handlingsregelen*. This rule states that the limit of use is bound to only 4 % of the interest. This means that we only spend an acceptable amount of the interest *without consuming from the resource itself.* This principle is basically the same as what is required in the use of renewable resources: Think of the description for the four different ecosystem services: The supporting services comprise the ability of an ecosystem to remain as it is, reproduce its own functions, and continue to provide the same services over time. If we do not degrade the resource itself we can reap the surplus and not contest the future ability to reap. This is a principle that all political parties in Norway stand behind, with the exception of one wing within Fremskrittspartiet, a populist party on the right wing. This should mean that it is within the capacity of most people to accept the same principle for natural resources. Arguably, this means that protection of environmental capacities is already agreed upon in the public.

Then, why is the protection of natural resources still controversial? A possible answer to this is that politicians cannot trust that this principle is well communicated and understood in the public and that people will recognise this as the responsible choice on behalf of this and future generations. If this is the case the solution should to improve the communication of the scientific knowledge, and its political implications to the public.

However, this too has been questioned in debates over climate change. Many people are well informed on the topic, yet politically it is an immense task to implement cuts in CO2 emissions. Some authors connect this to the psychology of imminent and distance fears (e.g. Weber 2006). Psychologically people are more prone to worry about things that can strike at any moment; for instance being hit by a car or getting

the flu before an exam. Abstract environmental issues causing problems in an undefined window of time in the future does not generate a sense of urgency.

Nevertheless, abstract environmental problems are causing problems *right now*, and this must be made clearer. Events like hurricane Sandy increase peoples concerns about climate change in the United States. Climate change tipping the sugar kelp stock out of balance in the Skagerrak, impairing coastal ecosystems is happening right now and can be communicated better.

The logic behind the budgetary rule in the oil fund shows peoples willingness to accept constraint for the sake of sustainability. Public support for environmental action may therefore be a question of communicating the importance of it. The example in Mee *et al*. (2008) suggests that a central issue is to highlight the connection between environmental degradation and impacts in the socio-ecological system. Connecting the issue of water pollution with biodiversity loss and the implications, for example for fisheries, gives a clearer picture of the consequences of human actions and increase incentives to contribute as individuals as well as supporting sound environmental policy.

8.4 Scientific recommendations and feasibility

So far the reasons for sugar kelp loss have been addressed, along with discussions on uncertainties and management responses. The scientific literature state that measures in reducing runoff from agriculture, sewage and surface water is necessary to achieve a better condition along the Skagerrak strait (e.g. Moy *et al.* 2008). Within the existing management framework this is being addressed, although improvements can be made in the management framing. Moy *et al.* (2008) claims that from a theoretical point of view there is no possibility of these measures reversing the effect of a regime shift. This means that what we are facing is likely to be a permanently changed ecological state.

However, there are more recommended mitigating measures that involve action on the coast directly. Although reversing is not likely to be an option, there is still room for improvements. Moy *et al.* (2008) point to the link between sugar kelp and overfishing of cod, elaborated on in the first analysis chapter. They point out that the

implication of this is that this is an internationally shared problem as the cod quotas are shared within the EU.

Further, Moy *et al.* (2008) recommends wider experimentation of measures in the coastal zone of the Skagerrak. Their assessment is that the coastal zone here is so degraded that it may need extra initiatives to revitalise it, apart from improving water quality and cod stocks. Possibilities are cultivation of sugar kelp on artificial reefs and establishing green oases. This can interrupt the self-reinforcing negative trends. There have been experiments where reefs have been put out without the cultivation of sugar kelp. Then the reefs are populated by nearby species, some places filamentous algae. Since the sugar kelp is the wanted species cultivation is an option. An artificial reef with sugar kelp has the potential to repopulate surrounding areas over time. However, for this to have a wider effect this measure must be implemented on a wide scale.

The question then is feasibility. Who should be involved and from where should the funding come? The current institutions that are involved are knowledge institutions, like the Institute of Marine Research and the Norwegian Institute for Water Research, and policy institutions like the Climate and Pollution Agency. For this to be followed up on a long term, it could perhaps be integrated with the water management in the sub-districts that encompasses the coast. Collaboration between research institutions and the sub-districts are already common practice. As for funding, it would require government support.

This suggested solution, however, is based purely on the existing system. If such a project were to take an Integrated Coastal Zone Management form, how would it look?

Looking to the framework of ICZM and adaptive co-management stakeholder participation becomes central. There is a level of stakeholder participation in the cooperation across levels and sectors in the public management, and also in the cooperation with scientific bodies. However, stakeholder participation can also be used to locally anchor efforts and increase the support for an integrated effort. Looking to each locality is important in identifying actors that may contribute in the process. Stakeholders could be recruited from scuba diving clubs, schools, the tourist

sector, local wildlife organisations, outdoors recreation groups, scouts and many more. It is at the local level that the range of relevant stakeholders becomes apparent.

There have been attempts for this type of cooperation already. NIVA (2011) reports that they included school children in mapping biodiversity and taking water samples from littoral pools: Small dams on land that contain a mix of ocean spray and rainwater. Pools of a greater size have a very special ecology and contain species that can cope with extreme fluctuations in temperature and salinity. They are also very accessible, which made it possible to have youth and children help mapping them. However, NIVA reports that the experience with involving schools in this mapping was mixed and thus the project have been abandoned. A thorough evaluation of why the project failed would have been interesting in order to identify strategies to make it work. This is a central point; if one does not learn and adjust the project along the way, it is not an adaptive approach to stakeholder participation.

A source in NIVA told me that they had also collected tips from individuals, particularly ornithologists. This has been useful in locating eelgrass fields as birds, for example swans, thrives in areas with eelgrass.

Greater involvement of stakeholders has the potential of clarifying the needs in management and science, allowing civic society to contribute. It also anchors the management process locally, increases public support and empowers people in the process.

9 CONCLUSIONS: CONNECTING THE DOTS

The aim of this thesis was to explore the challenges to the Norwegian management of complex environmental problems, seen through the example of sugar kelp decline. To address this I chose to look closer at how agricultural runoff is managed. By looking at the Norwegian implementation of the EU water framework directive, I have found examples of how Norwegian management adapts to address complex environmental problems. As a conclusion I will summarise some of the challenges and lessons that has been brought up in this thesis.

Disentangling environmental issues from one another is difficult because they are all related, and disconnecting them from social systems is next to impossible. In the process of describing the issue of sugar kelp decline I have touched upon a whole spectre of other environmental problems, spanning from global climate change, to the effect of wrasse predation on grazers. Most of these problems are directly or indirectly connected to anthropogenic influence. Savory & Butterfield (1999:17, italics in original text) say that management of any system requires "looking inward at the lesser wholes that combine to form it, and *outward to the greater wholes of which it is a member*". This quote captures the complexity of environmental issues. The network of influences across species, habitats and their living conditions is interlinked with human practice in a socio-ecological system. To enhance resilience of this system calls for adapting the management approaches, limiting negative impacts on human and natural systems.

What is clear from the research in this thesis is that bureaucratic processes can take time. In 1993 Norway ratified the Convention on Biological Diversity. It took a decade before the National Programme for Mapping Marine Biodiversity was initialised, a programme that is crucial to start monitoring biodiversity in order to account for the biodiversity loss. With ecosystems that may reach tipping points, there is a need to accelerate the speed at which action is taken. As well, management regimes change slowly, and the current framework cause a lot of conflicts over responsibility between sectors and levels. The decline of sugar kelp reveals complex patterns in socio-ecological systems, and addressing it involves balancing many concerns at the same time.

Large structural changes are required, for example a massive restructuring of agriculture in the east of Norway, where crop rotations with co-located livestock and cereal production would contribute to sustainable land use. However, informants with insight in the agricultural sector do generally not consider restructuring to be feasible, due to expenses, as well as resistance within the sector.

The informants own suggestions point to the need to enforce new legislation to reduce runoff from agriculture, such as prohibition on autumn ploughing on erosion class 3 and 4, and increased buffer zone from water bodies. A central problem is the exclusively voluntary form of agricultural measures that is inadequate to reduce runoff. Another problem with the use of regional environment programmes (RMPs) is that the rotation every four years makes predictability of financial support from the government low. The prioritisations in the RMP are depending on the political climate, and changes in the government can change which measures that will receive support. Thus the current practice of using the RMP is to some extent unsatisfactory both for water managers and for farmers.

Acknowledging that socio-ecological systems cross scales and socially constructed categories, the sector approach to environmental management is no longer appropriate. The current capacity of the management system is compromised by conflicts. A way to address this would be to establish a management practice that is more sensitive to agreement and targeted measures. For different sectors to recognise needs in adjacent sectors, a holistic approach can be applied. This is attempted, for example through the new management plan for the North Sea and Skagerrak. However, this plan has a delimited scope, and many factors causing negative effects are considered as external to the plan. The weakness of this is that the holistic approach is not guaranteed in the other sectors.

When stakeholders from different sectors are outside the decision-making process, their concerns are not thoroughly advocated. Thus a central goal for the government is to find ways to integrate management between sectors with conflicting interests, for example by asking the Ministry of Agriculture and Food to cooperate with The ministry for Fisheries and Coastal Affairs. By actively addressing conflicting interests

in a cooperating management framework, there is more room for encountering innovative solutions and acceptable compromises.

Implementing new paradigms in management and policy is very demanding. Management is a social process where people with different knowledge, backgrounds, experiences and opinions work within a system together. They both shape and are shaped by the frameworks they work within. The Swedish example discussed in chapter eight, where a municipality attempted to use an ICZM strategy, showed that changing the management practice was very hard. Different stakeholders were not involved, and cooperation between sectors and levels were limited (Storbjörk & Hedrén 2013). The example demonstrates that it may be naïve to expect management to change quickly in spite of implementing new management frameworks.

At this time, accessible knowledge indicates an urgent need for action, yet the thirst for perfect knowledge seems to be slowing this down. From the discussions in chapters six and seven it becomes clear that knowledge is contested, and uncertainty sometimes used to achieve pre-defined goals. With the precautionary principle as a beacon, examples of questionable use of knowledge should be debated thoroughly and openly. By addressing one issue at the time we risk creating new problems along the way. An example is reduced autumn ploughing in conventional farming leading to an extended use of pesticides. Ravetz (2004) points out that the amount of pollutants dumped into the environment has reached such a level that retrospective testing of pollutant levels, and assessing cross effects of being exposed to many pollutants, is no longer possible. He connects this to the practice in the industrial economy of applying innovations that are not proven harmful, yet not proved to be safe. An appropriate response to this would be to take a greater precaution as the wider environmental effects of increased pesticide use in time and space is not known.

O'Riordan (2000) stresses the need to involve stakeholders in order to achieve consensus in management practice. As the environmental issues span far in time and space, solutions must be found that connect the global and the local perspective. He further advocates the need for interdisciplinarity in this context. The holistic approach outlined above can be used on a government level. In local contexts however, stakeholder participation can involve more actors. In the co-production framework,

stakeholder participation takes interdisciplinarity further. This is a part of post-normal science that claims that human values are central, also outside of academia. The participation of locals and stakeholders is intended to anchor the efforts and become part of civic value systems.

Opinions on stakeholder participation in adaptive management strategies vary greatly. Pessimists claim that stakeholder participation will stall projects already at the planning table. Optimistic voices in the debate argue that such participation embeds the importance of sustainable development at local levels. This, it is claimed, ensures further protection of both biodiversity and economic and social development. Schultz *et al.* (2010) show that representatives from both views have found examples to underpin their view. Thus, this can be seen as a strategy that can turn both ways, indicating that there are many preconditions that must be met for it to work.

How the management approach will develop over time is uncertain. Norwegian water management in accordance with the WFD has only just started. In 2013, all sub-districts will start the implementation phase. The counties can expect far more voices to advocate their needs in coastal affairs, and this is likely to cause an improvement for sugar kelp. The focus on coastal affairs in inland sub-districts is low, but with further cooperation with the sub-districts that manage areas with sugar kelp this focus can be enhanced. The knowledge base is currently very big, but the management of it can be improved.

With a global environment that is subject to massive changes that are difficult to understand and predict, coastal management will need extra attention in the time ahead (Ricketts 2009). Global climate change is causing sea level rise due to the melting of glaciers and thermal expansion of water, a development that will continue even if the release of greenhouse gases is stopped (IPCC 2012). The new plan 'Holistic management of the marine environment in the North Sea and the Skagerrak' (The Ministry of the Environment 2013) does not focus on sea level rise, possibly because the scope of the plan is open water, and sea level rise is considered a more direct problem in the coastal areas. However, the plan does take in some issues linked to global climate change, like increased water temperatures and ocean acidification. It further addresses other important issues, like marine litter and plastics, toxic waste,

sugar kelp loss, fish stocks and several more. It clearly collects a lot of knowledge, an important step for management.

However, whether the new plan is sufficient as a policy tool remains to be seen. It depends on the management in sectors that are external to the plan. In talking about discrepancy between stated goals and the framing of the implementation one of my informants said:

> "You don't fly to the moon just because you say: 'Now I'm flying to the moon'."

For a holistic approach, more sectors must agree to frame their policies holistically. As well, knowledge transfer from many fields is necessary.

O'Riordan (2000) emphasises the need for the hard sciences to work with sensitivity to local participatory management. The information that is produced must be contextual as well as understandable to allow findings to be integrated with practice. This integration also calls for input from the social sciences. Management systems takes time to build capacity and the work is painstakingly slow due to institutional lag as well as power struggles over trade-offs and what is acceptable to sacrifice for the sake of the environment.

The new management plan is already facing criticism: Only weeks after its release local units along the Skagerrak coast of the Norwegian Society for the Conservation of Nature published a petition to increase the government's efforts in the Skagerrak (Schulze 2013). They argue that in spite of the plan clearly stating the serious problems, particularly sugar kelp loss, it is not concrete enough in its actions to improve the situation. I connect that criticism to the delimited scope where only marine areas outside of the coastal areas are involved. This is not sufficient for holistic management. Therefore a prerequisite for it to work is that the other sectors take in the concerns of this management plan and integrate the outlined challenges in their policy.

> "Each day counts. The actions taken by individuals, stakeholders and governments are important steps, one building on the other, towards protecting the life support

> systems that not only ensure human well-being, but support the rich variety of life on this planet." (United Nations Decade on Biodiversity, undated)

The future holds great challenges in the years to come, for science, management and society. Loss of biodiversity is connected to large-scale changes, but the outcomes are experienced locally (Jentoft 2009). To mitigate and adapt to environmental problems new approaches are required.

This thesis addresses many of the difficulties with adapting management approaches to face current environmental problems. The question of whether we can afford to make the necessary adaptions should be turned around. In line with the planetary boundaries discourse presented by Rockström *et al.* (2009), one can argue that we cannot afford *not* to change. The large-scale changes in the environment that are caused by human activity are undermining the ecosystem services humans rely on. However, the social systems locally and globally distribute the consequences to human livelihoods unequally across the globe, but are also injuring Norwegian socio-ecological systems. Sugar kelp loss was an unanticipated problem, and the lesson to be learnt from it is that we may not know what we are losing until it is too late.

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11 APPENDIX 1

11.1 Short definitions

Anoxia: Oxygen depletion to the extent that there is no oxygen left.

Baseline: The straight line drawn between the headlands and islands marking the outer edge of the coast. In Norwegian: *Grunnlinja*.

Ecosystem services: The benefits to humans provided by ecosystems. Commonly divided into provisional, cultural, regulating and supporting services. Further elaborated on page **Feil! Bokmerke er ikke definert.**.

Epiphytic algae: Algae that grow on other plants.

Filamentous macro alga: Type of algae that replace sugar kelp. It forms fragile threads and prefers sheltered waters as wave exposure tears them apart. They are commonly ephemeral; meaning that they are short lived, thus not providing consistent vegetation throughout the year. opportunistic

Mariculture: The type of aquaculture primarily used in Norway where the fish are kept in cages in the open sea.

Nature: Commonly the conception of the environment outside of human influence. Nature can be viewed as the 'other' of humans, or it can be included as a part of a culturally contingent concept. The understanding of nature determines the balance between use and conservation, thus it is important to reflect upon. This is further debated on page **Feil! Bokmerke er ikke definert.**.

Positive feedback: When a small disturbance in a system affects other system components that in turn reinforces the first disturbance, for example climate change causing thaw of permafrost areas releasing methane into the atmosphere and further contributing to the climate change. Thus the positive feedback is a self-reinforcing loop of events.

Socio-ecological systems: The notion that human and environmental systems are interdependent, and that they are adaptive, complex and cross scales (Schultz *et al.* 2010). Elaborated on page **Feil! Bokmerke er ikke definert.**.

Sustainable development: "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development 1987:43). A critique of the term is found on page **Feil! Bokmerke er ikke definert.**.

Wrasse: Species of small fish, that increase in numbers with reduction of predating species. Increasingly captured live and used in mariculture to eat parasites like salmon lice.

11.2 Abbreviations

CBD: Convetion on Biological Diversity

IPCC: Intergovernmental Panel on Climate Change

KLIF: The Climate and Pollution Agency

NIVA: The Norwegian Institute for Water Research

NBIM: Norges Bank Investment Management

NNI: The Norwegian Nature Index

WFD: The EU Water Framework Directive

12 APPENDIX 2

12.1 List of images, maps and figures

12.1.1 Images

Image 1: Sugar kelp in 1992, replaced by filamentous macro algae by 2002. Adapted from Moy *et al.* (2009:19) with permission.

Image 2: Left: Sugar kelp overgrown with filamentous macro algae. Right: Filamentous macro algae without the presence of sugar kelp. Adapted from Moy *et al.* (2009:20) with permission.

Image 3: Left: Sugar kelp overgrown with epiphytic algae. Right: Healthy sugar kelp blades. Adapted from Moy *et al.* (2009:20,iv) with permission.

12.1.2 Maps

Map 1: Map of the Skagerrak: Retrieved from Wikimedia Commons under the terms of the GNU Free Documentation Licence (version 1.2).

Map 2: Map of the Glomma river basin district with 14 sub-districts. Adapted from vannportalen.no

12.1.3 Figures

Figure 1: Schematic figure showing possible links between influencing factors and the presence of sugar kelp. Adapted from The Climate and Pollution Agency (2009:20).

13 APPENDIX 3

13.1 Sample of interview questions.

This sample is translated from the Norwegian version. All interviews were conducted in Norwegian, and the interviews were semi-structured, meaning that I would jump to a topic further down on the list if this depending on where the conversation led. I would go back to address the topics that were not yet discussed.

Key words of interest:

WFD, Red lists, Nature Diversity Act, municipal planning, The national program for mapping marine biological diversity, the sugar kelp monitoring programme, interest after massive decline in 1997, the Skagerrak, low temperatures, lots of light, eutrophication, ERA, RMP.

- Can you tell me a little about your background and your position?
- How do you work with water management?
    - How do you work within the region?
    - The roles of the counties
- How do you cooperate with the sub-districts within the county?
- How has water management changed with the implementation of WFD?
    - What were your tasks before and what are they now?
- How was your department involved when the Regional Environment Programme was formed?
    - Cooperation between the departments in the counties?
    - Cooperation between the different counties?
- What are the other tasks with water management apart from those connected to? Agriculture?
    - Edges to surface water?
    - Grass cover to reduce risk of erosion?
    - Sewers?
    - Options to process urban runoff?
    - Prevention of landslides?
- What sources of information/scientific resources do you use?
    - NIVA, Bioforsk, UMB, Measurements during floods?
- Do you cooperate with representatives from businesses?
- Are there any debates going on regarding the distance to surface water agriculture is allowed? (the 2 meter-rule)
- What opportunities do you have to influence:
    - Businesses? Counties? Municipalities? Farmers?
- Are there any focus on the consequences for the marine areas?
- What are the values you operate with? Primarily monetary value, or other natural values?